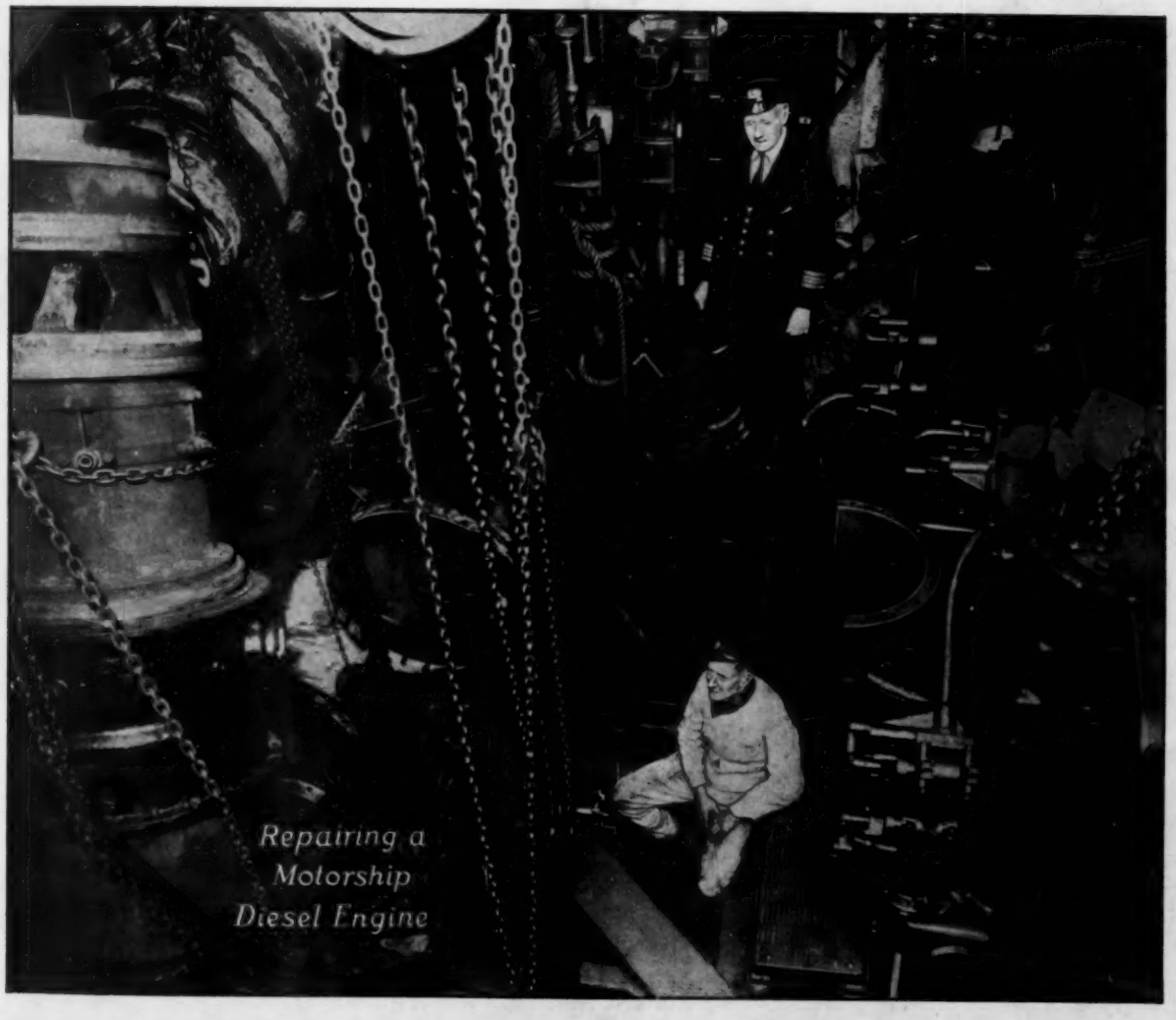
IN TWO SECTIONS—SECTION ONE

ENGINEERING LIBRARY

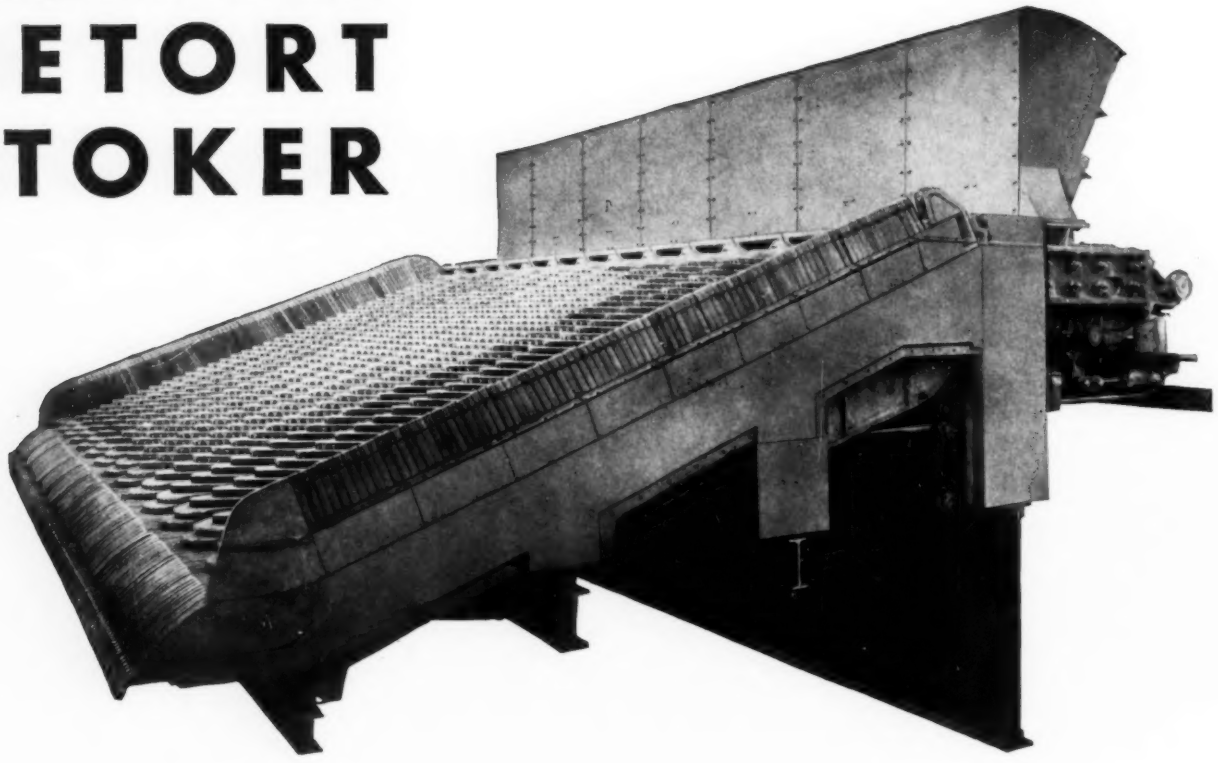
MECHANICAL ENGINEERING



Repairing a Motorship Diesel Engine

August 1929

A BETTER MULTIPLE RETORT STOKER



The C-E Multiple Retort Stoker possesses important advantages of design and construction which are evident to those who have had the opportunity to examine it. • The character of its performance is revealed in the operating records of existing installations. • Translated into actual performance, the results of the many new features embodied in this stoker are —

NOTABLE SMOOTHNESS AND RELIABILITY OF OPERATION • LOWER AIR PRESSURES
EASIER AND MORE ACCURATE CONTROL OF MOVING PARTS
HIGHER FUEL BURNING CAPACITY • IMPROVED OPERATING EFFICIENCY
MORE EFFECTIVE ASH DISPOSAL • LOWER MAINTENANCE COSTS

Because of these results, the performance of the C-E Multiple Retort Stoker represents a definite advance over present-day standards in the multiple retort stoker field.

• • •

Your copy of the new catalog, describing the C-E Multiple Retort Stoker, is awaiting your request.

COMBUSTION ENGINEERING CORPORATION

International Combustion Building • 200 Madison Ave., New York

A SUBSIDIARY OF INTERNATIONAL COMBUSTION ENGINEERING CORPORATION

Mechanical Engineering

The Monthly Journal Published by

The American Society of Mechanical Engineers

Publication Office, 20th and Northampton Streets, Easton, Pa. Editorial and Advertising Departments at the Headquarters of the Society, 29 West Thirty-Ninth Street, New York

Volume 51 | August, 1929, Section One | Number 8

CONTENTS OF THIS ISSUE

Commercial Applications of High-Speed Oil Engines — *C. H. Gibbons* — 571
Maintenance and Repair of Marine Diesel Engines — *L. R. Ford* — 576
Aircraft for Passenger Transport — *C. N. Monteith* — 581
Research in the Engineering Colleges — *W. E. Wickenden* — 585
Recent Developments in Boiler-Metal Embrittlement — *H. F. Rech* — 589
Friction of Journal Bearings as Influenced by Clearance and Length — *S. A. McKee and T. R. McKee* — 593
Journal Running Positions — *H. A. S. Howarth* — 595
Tungsten Carbide Cutting Tools — *H. J. Long and W. P. Eddy, Jr.* — 596
Present Status of Tungsten Carbide as a Cutting Material — *F. C. Spencer* — 597
Steam-Generating Apparatus in Forest Areas as Related to Causes of Forest Fires — *A. C. Coonradt* — 599
Cooling and Lubrication of Cutting Tools (Progress Report No. 1) — 604
An Early American Locomotive — 607
The Teaching of Advanced Mechanics in Engineering Schools — *S. Timoshenko* — 609
Advanced Mechanics in the Electrical Industry — *J. Ormondroyd* — 610
Worcester Reed Warner Dies — 634
Synopses of A.S.M.E. Transactions Papers — 638

DEPARTMENTAL

Survey of Engineering Progress — 614
The Most Economical Steam Pressure for Central Stations, Assuming the Use of the Löffler Boiler; Short Abstracts of the Month
Engineering and Industrial Standardization — 626
Résumé of Development of International Cooperation in Standardization Work to May 1, 1929
Work of A.S.M.E. Boiler Code Committee — 627
The Conference Table — 628
Correspondence — 629
Wages of Engineers
Editorial — 630
Reduction of Forest Fires; Tungsten Carbide Tools; Boiler Feedwater Studies; Research in Sound; Mr. Employer; Television and Mechanical Control; Powdered Fuel and the Stoker Through German Eyes; Teaching Advanced Mechanics; Automobile Accidents—Their Cost
Book Reviews and Library Notes — 636
The Engineering Index — 641

ADVERTISING

Display Advertisements — 1
Classified List of Mechanical Equipment — 32
Professional Engineering Service Section — 122
Opportunity Advertisements — 126
Alphabetical List of Advertisers — 128

Section Two—News of Mechanical Engineering

Price 60 Cents a Copy, $5.00 a Year; to Members and Affiliates, 50 Cents a Copy, $4.00 a Year. Postage to Canada 75 Cents Additional; to Foreign Countries, $1.50 Additional. Changes of Address should be sent to the Society Headquarters.

Entered as second-class matter at the Post Office at Easton, Pa., under the Act of March 3, 1879.
Acceptance for mailing at special rate of postage provided for in Section 1103, Act of October 3, 1917, authorized on January 17, 1921.

Copyrighted, 1929, by The American Society of Mechanical Engineers

A. C. Coonradt

L. R. Ford

C. H. Gibbons

H. F. Rech

S. Timoshenko

Contributors to This Issue

C. H. Gibbons, advertising manager of the Marion Steam Shovel Co., Marion Ohio, has been associated with the excavating-machinery industry and other heavy-machinery lines since 1910. The unusual application of the high-speed oil engine to excavating machinery by the use of the direct-current electric interlink, with the development of which the author has been closely associated, adds interest to the paper.

L. R. Ford, upon completing his apprenticeship in the machinist trade, entered the United States Navy as a machinist, second class, passed through the various enlisted grades to warrant rank, and in 1912 passed his examination for ensign. He was commissioned with the Naval Academy class of that year, and after a year's service at sea was assigned to take a post-graduate course in engineering at the Naval Academy and Columbia University, receiving his M.A. from the latter in 1915. He served throughout the World War in the submarine force and in 1919, after 17 years' service in the Navy, resigned as Lieutenant Commander to become associated with the Worthington Pump & Machinery Corporation as chief operating engineer. In 1922 he resigned from this position to take charge of the Diesel engineering activities of the Morse Dry Dock & Repair Co., now a unit of the United Drydocks, Inc., and to establish a general consulting practice.

C. N. Monteith, who writes on "Aircraft for Passenger Transport," holds the position of chief engineer of the Boeing Airplane Co., in Seattle, Wash.

W. E. Wickenden is director of investigation for the Society for the Promomotion of Engineering Education. He served for two years as assistant vice-president with the American Telephone & Telegraph Co. before accepting his present position. In the fall of this year Mr. Wickenden is to become president of the Case School of Applied Science.

H. F. Rech has for the past three years been associated with the General Motors Corporation in the power and maintenance section of its Works Manager's Committee. For fifteen years Mr. Rech was connected with the Detroit United Railway, starting in the laboratory, and becoming combustion engineer for all of the company's plants. He was then appointed assistant chief engineer of the two Detroit power stations, and during the last four years of his service was superintendent of power.

S. A. McKee and **T. R. McKee** hold the positions respectively of assistant mechanical engineer and research associate in the Bureau of Standards, Washington, D. C.

H. A. S. Howarth is vice-president and general manager of the Kingsbury Machine Works, Inc., in Frankford, Philadelphia, Pa.

W. P. Eddy, Jr., has recently joined the Brown-Lipe Chapin Co. as assistant metallurgist. Previously, he was connected with the Geometric Tool Co. of New Haven for five years, and before that was associated with the Crucible Steel Co. of America.

H. J. Long has been with the Brown-Lipe Chapin Co. a number of years and is now its chief experimental engineer.

F. C. Spencer is assistant superintendent in charge of machinery procurement of the Western Electric Co. In 1906 he entered the employ of the Western Electric Co. as machine designer, and has been connected with this company since that date, except for a few years during the war when he was superintendent of the Browning machine-gun department of the Colt Patent Fire Arms Co.

A. C. Coonradt, assistant professor of mechanical engineering, New York University, was graduated in mechanical engineering from Stanford University in 1909 and for the next seven years was connected with the Portland Electric Power Co., in Portland, Ore., engaged in power-station design and power sales work. He resigned from this concern to become sales manager of the Grays Harbor Railway & Light Co., at Aberdeen, Wash. His acquaintance with forestry was gained while acting as sales engineer for the Lamb Machine Co., manufacturers of logging equipment, and as a designer with the Lidgerwood Manufacturing Co. in Seattle. In 1923 he became an instructor of mechanical engineering at Oregon State College, and while there carried on the spark-arrester survey work for the Pacific Northwest District. He then entered New York University to take graduate work in aeronautical engineering, and later obtained his A.E. degree.

S. Timoshenko, formerly associated with the research department of the Westinghouse Electric & Manufacturing Co., and now professor of mechanical engineering at the University of Michigan, received his degree of C.E. in 1901 from the École des Ponts et Chaussées of St. Petersburg, Russia.

J. Ormondroyd received the degree of A.B. from the University of Pennsylvania in 1920. Since then he has been connected with the Westinghouse Electric & Manufacturing Co. as engineer. For two years his duties related to electric-heating engineering, and since 1924 to railway-motor engineering. He has been engineer in charge of instruction in the Westinghouse Mechanical-Design School since 1927.

This Month's Cover shows the difficulties involved in the removal and replacement of a cylinder liner in the restricted space available in a motorship engine room. It is used in connection with L. R. Ford's paper in this issue on marine Diesel engines.

MECHANICAL ENGINEERING

Volume 51 August, 1929 No. 8

Commercial Applications of High-Speed Oil Engines

By C. H. GIBBONS,[1] MARION, OHIO

The author discusses the possible application of high-speed Diesel engines to aircraft, trucks, and tractors, and gives details of their application to locomotives, generating sets for city buildings, cotton ginning, oil-well drilling, pipe-line pumping, irrigation, marine propulsion, air compressors, dredges, excavating machinery, etc. He also deals with medium-speed applications and gives data for use in estimating power costs.

A YEAR ago at this meeting there was presented an excellent analysis of the economic field for small and medium-size Diesel engines.[2] The past year has indicated the desirability of a somewhat different approach to the same general subject. The trend toward higher speeds has been quite marked, until today rotative speeds of 1000 r.p.m. and piston speeds of 1350 ft. per min. are not unusual in commercial applications; and experimentally, in a truck Diesel, in Germany, rotative speeds of 2500 r.p.m. have been attained. In addition the number of commercial installations of high-speed Diesels has been increasing. Authentic data as to operating costs continue to be difficult of discovery, as are all costs of manufacture, whether of machinery or of power.

The economic factors which have dictated the Diesel have been enumerated and expanded upon so frequently as to merit little more than a mention in passing. In comparison with the gasoline-fueled engine, the wide range of fuels and their generally lower cost per unit; greater thermal efficiency with attendant smaller radiators; more perfect combustion with less carbon deposition and less valve distortion; ease of starting; advantageous speed-torque characteristics; lower fire risk; simpler construction, particularly in respect to both mechanical and electrical phases, have all had adequate handling, as has also the reduced radio interference in aircraft service.

Distinct Demand for a Light, High-Speed Diesel

There is a distinct and insistent demand for a high-speed Diesel which with equal reliability will take the place of the gasoline engine and will occupy little or no more space and weigh little or no more. The long period of education in the use and operation of gasoline engines will be capitalized—it will not take much education or effort to train one acquainted with the gas engine's peculiarities to understand and properly handle the high-speed Diesel. In reality it is simpler in construction, and once the principle is grasped, the rest follows readily.

As to applications commercially, in the aircraft field there have been none. Certain very promising experiments have been performed and the actual flying of a Diesel-motored plane for several hundred hours has been effected, but it is not correct to state that the application is a commercial one. An excellent discussion of the subject may be found in the *S.A.E. Journal* for February, 1929.

Trucks

There have been no commercial applications to trucks in this country, although in Germany they have been in use for a number of years, and more than 100 are in regular service. One builder of high-speed Diesels in this country has installed one of his engines in an ordinary four-ton truck. This was accomplished without extension of hood or change in radiator. In competitive service for the past three years and in the hands of regular truck drivers and at temperatures ranging from —10 deg. fahr. to 95 deg. fahr., this truck has shown a fuel-consumption ratio of 3 to 8 as compared with a similar gasoline-equipped truck and a lubricating-oil consumption ratio of 3 to 4. Or with gasoline at 20 cents and Diesel oil at 6 cents per gal., the fuel costs are as 1 to 9. The Diesel-engined truck is particularly effective on the hills as its speed-torque characteristic is much better at low speeds than that of the gasoline engine. This results in less gear shifting and in smoother operation. The distance covered per gallon was $10^1/_2$ to $11^1/_2$ miles.

While not exactly a commercial application, the following record should be included. A $5^1/_2$-ton Diesel-powered truck made a round trip of 1500 miles from New York to Detroit. This truck was motored by a 70-hp., 6-cylinder, 105-mm. bore × 165-mm. stroke Diesel, running at 1300 r.p.m. (18.6 m.p.h.). It consumed 115 gal. of furnace oil and 1 gal. of lubricating oil, or about 13 miles per gallon of fuel. The engine showed a fuel consumption at full load of 0.456 lb. per b.hp-hr. In handling, both on the open road and in congested city traffic, flexibility equal to that of the usual gasoline truck was readily had, while on the hills the Diesel was noticeably better than a similar gasoline-powered unit.

Tractors

A prominent manufacturer of tractors in the Middle West has just put into service a tractor equipped with a high-speed Diesel engine, but as yet no data are available in regard to operating costs. No particular problem was involved in this application beyond the necessity of strengthening the chassis and gear trains, together with clutches, etc. This necessity arises from the sharply increased torque at low speeds as compared to the gasoline engine formerly used. This increase for a given speed amounts to as much as 30 per cent.

---

[1] Advertising Manager, The Marion Steam Shovel Company.

[2] In discussion on the subject led by H. A. Pratt. Mem. A.S.M.E.

Presented at the Second National Meeting of the A.S.M.E. Oil and Gas Power Division, State College, Pa., June 24 to 27, 1929. Abridged.

Note: Statements and opinions advanced in papers are to be understood as individual expressions of their authors, and not those of the Society.

Locomotives

In the internal-combustion-engined locomotive field one of the outstanding applications has been that of Diesel-powered switching locomotive for the Long Island Railroad. This is a 660-hp. 87-ton Baldwin-Westinghouse unit with two Westinghouse-Beardmore engines which are light-weight, high-speed, 6-cylinder, 4-cycle, solid-injection units weighing, with flywheel, about 7000 lb. each or 21.2 lb. per b.hp. Their operating speed ranges from 300 to 800 r.p.m. The maximum speed is 30 m.p.h. with 38-in. diameter drivers. The maximum tractive effort is 49,500 lb. No operating cost data are available.

On the Manchester-Bury line of the London, Midland & Scottish Railway a Diesel-electric locomotive equipped with a 500-hp. high-speed Beardmore Diesel direct-connected to a 350-kw. 600-volt generator recently went into service. The traction motors are two in number, each of 280 hp., and one is mounted on each of the trucks. The engine has four speeds; viz., "idling" at 350 r.p.m., intermediates of 600 and 750 r.p.m., and a full-load speed of 900 r.p.m. No operating cost data are yet available.

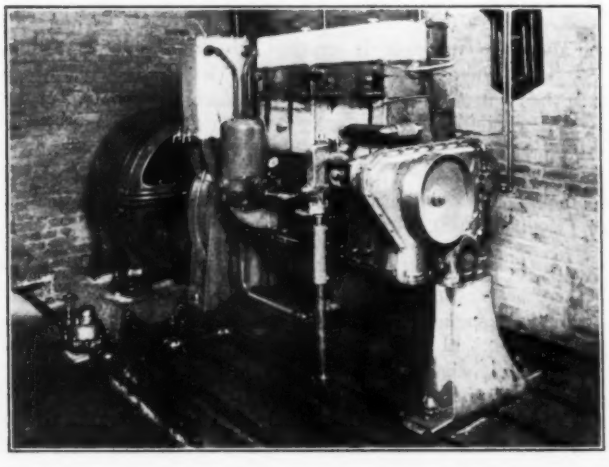


Fig. 1 4-Cylinder, 92-Hp., Solid-Injection Diesel Engine Direct-Connected to a 65-Kw., 900-R.p.m., 250-Volt A-C. Generator

At Akron, Ohio, the Erie Railroad has in switching service an A.L.G.E.I.R. Diesel-powered locomotive which has given very satisfactory service. These Diesels, of which there are two, are 6-cylinder, 10 in. × 12 in., and rated at 250 hp. each. The speed is 580 r.p.m. and the connection is direct to two 200-kw. d-c. generators. The weight of this unit ready for service with water, oil, sand, etc., in their respective receptacles is 117 tons, and the dynamometer test revealed a tractive effort of 73,500 lb. or 22 per cent of the total weight. The maximum speed is 30 m.p.h. The availability ratio is 93 per cent, while maintenance and repairs amount to 25 cents per locomotive-hour, of which the greater part is labor. Fuel oil and lubricating oil are supplied for 50 cents per locomotive-hour. It is difficult in this service to reduce costs to ton-miles or to any of the usual yardsticks of measurement.

A notable application is that of the Canadian Locomotive-Westinghouse-Beardmore 2660-hp. high-speed Diesel locomotive on the Canadian National Railways between Brockton and Belleville, Ontario. This locomotive consists of two units weighing 325 tons, of which 240 tons are on the drivers. The continuous tractive effort is 42,000 lb., while during the acceleration period this effort is 100,000 lb. This locomotive is powered by two 1330-hp., 12-cylinder, 12-in. × 12-in. variable-speed Diesels. The idling speed is 300 r.p.m. and the full speed 800 r.p.m. They develop their rated horsepowers at 0.43 lb. of fuel oil per b.hp-hr.

An interesting and important detail from the standpoint of thermal efficiency of the unit is the use of the exhaust gases from the engines in a boiler which develops steam for train heating. With engines at average load and with an average train, sufficient heat is saved to heat the train, although the outside temperature is as low as 12 deg. below zero (fahr.).

The locomotive carries 8000 lb. of fuel oil, 3000 lb. of jacket cooling water, 3000 lb. of sand, and 1000 lb. of lubricating oil.

A smaller-type narrow-gage locomotive has been in service for some time. This is a 12-ton locomotive equipped with a 92-hp., 6-in. × 8-in., four-cylinder, 1000-r.p.m. solid-injection engine. This has gear-driven construction, the various speeds being secured by a gear shift similar to the transmission of the automobile. An effort was made to secure operating cost data, but apparently no careful record has been kept.

Generating Sets

An application to generating sets is the so-called "Western Union" generating set, so named because it was developed to meet the need of Western Union buildings for a self-contained generating unit for use in various localities where by city ordinance the use of a gasoline engine in the basement of a building is prohibited. They are usually employed as stand-by units and have definite advantages also of small floor space and small head room. For example, a 100-kw. set needs a floor space of 42-in. × 165-in. and a head room of less than 90 in. over the radiator.

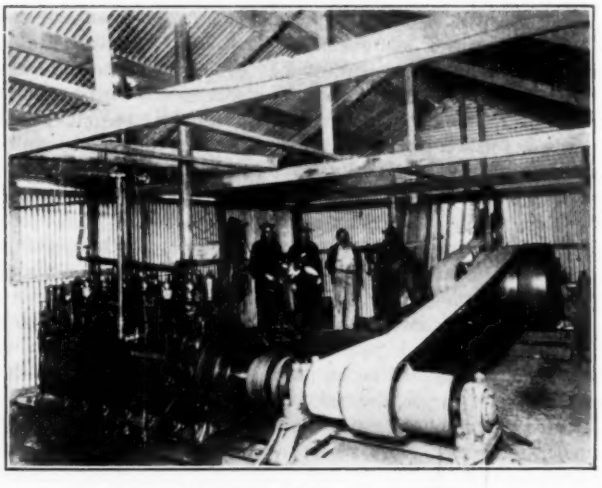


Fig. 2 6 × 6½-In. 800-R.p.m. 90-Hp. Diesel Used for Drilling a 5000-Ft. Hole at Pecos, Texas

(Engine is equipped with a special speed control operated automatically from bandwheel; engine speed increases through a portion of the bandwheel rotation.)

Another application consists of a 4-cylinder, 6-in. × 8-in. Diesel, direct-connected to a 65-kw., 900-r.p.m., 250-volt d-c. generator (Fig. 1). The demand on this generator varies w dely from very small currents up to 300 amperes. Service is 24 hours, 6 days per week, and the unit has been in service for two or three years. The cost of fuel and lubricating oil is as low as ½ cent per kw-hr. when using the lower grades of fuel oil. The floor-space required is 5 ft. × 10 ft.

An application in this field of a high-speed Diesel generating set is that of the Zipprich Teaming Company of Chicago who have a 2-cylinder, 6-in. × 6½-in. Diesel direct-connected to an 18-kw., 125-volt d-c. generator. This equipment with accessories occupies a space of 8 ft. × 10 ft in a basement whose

head room is only 86 in., yet there is ample room for removal of pistons, etc.

The operating record for the first 66 days showed fuel and lubricating costs of $1^1/_2$ cents per kw-hr. On the basis of these results a net saving annually on six 5-ton and one $1^1/_2$-ton electric trucks will be $1885. An interesting phase of this installation is the use of the heat of the exhaust gases to heat water for car washing, etc., about the garage.

In New York City at the present time there is a very active interest on the part of owners of buildings in the possibilities of high-speed Diesel generating sets because of the high costs of purchased power, because of the opportunities of heat reclamation from the jacket water and from the exhaust gases, and because of relatively low initial costs, low head room, and small floor space. While so far as the author knows there have been no installations, it is a field which is opening and one in which the manufacturer of the high-speed Diesel is particularly interested, because it is usually the case that there is no excess of space available for installation, especially when it is necessary to utilize the basements of existing buildings.

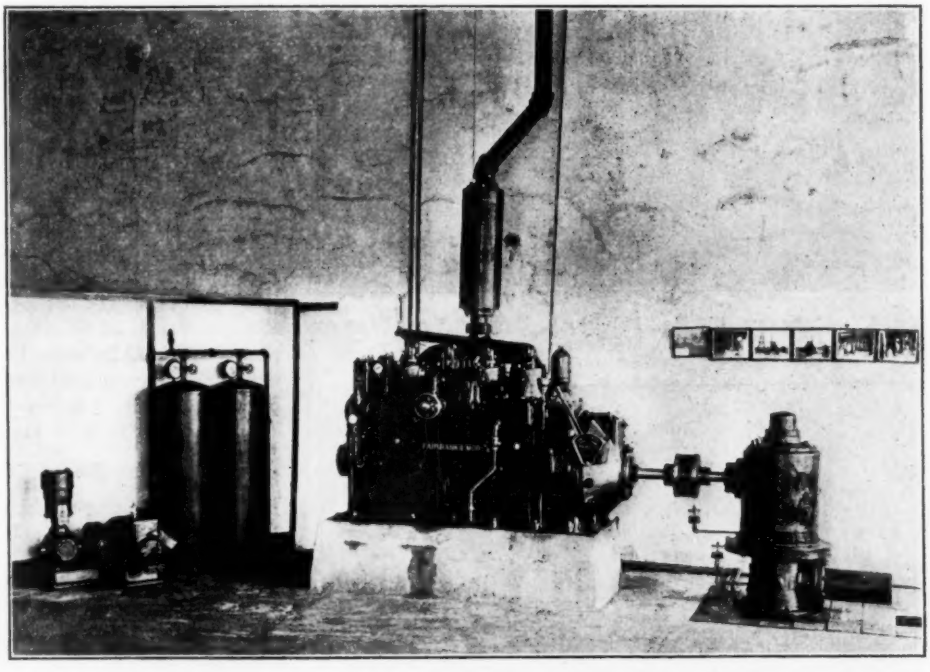


FIG. 3 A 4-CYLINDER, 6 × $6^1/_2$-IN., 60-HP. DIESEL ENGINE OPERATING AT 800 R.P.M. AND DIRECT-CONNECTED TO A SPECIAL ANGLE-GEAR UNIT FOR DRIVING A 14-IN. 5-STAGE TURBINE PUMP
(Units of this type are widely used in rice-field irrigation service in Arkansas and Louisiana and in other services where deep-well pumping is required.)

COTTON GINNING

In the cotton-growing states there have been numerous applications of the high-speed Diesel to cotton ginning. These are usually belted installations, and an unsuspected collateral advantage is secured. Because of its relatively light weight and small dimensions, the engine during the season when no ginning is being done is transferred to other work such as the operation of dredges or of irrigation pumps, etc. One user of such an engine—a 92-hp., 1000-r.p.m. Diesel—in Georgia states that he ginned 1804 bales, using 2245 gal. of 11-cent fuel oil and 40 gal. of 70-cent lubricating oil at a total cost for consumable supplies of $274.95 or 15.24 cents per bale. His ginning cost by electricity had been for the preceding year 63 cents per bale, a saving for the season of $861.59.

OIL FIELDS

A recent development of much promise and interest is that of the application of high-speed Diesels to oil-well drilling. These units (Fig. 2) are usually 4- or 6-cylinder, 60 and 90 hp., respectively, 6 in. × $6^1/_2$ in., and operated up to 800 r.p.m. They are usually skid mounted to effect ready portability and are belted to a countershaft carrying a clutch which in turn is belted to the bandwheel which carries the crank or lever which imparts to the walking beam its oscillating motion. The strong hold which steam has had on this industrial application has been due in part to the automatic speed variation achieved by steam throughout the cycle of one turn of the bandwheel. This consists of a speeding up following the fall of the tools in the hole and a reduction in speed during their rise. In addition the driller had a very complete control of average engine speed through the engine throttle. Both of these features are retained in this installation as there is a manual control by which the engine speed can be varied from 250 to 800 r.p.m. In addition there is a periodic control which varies the speed of the bandwheel each revolution thereof above and below the average speed which is under the control of the driller manually from the derrick floor. In this way also higher speeds for bailing, pulling tools, etc., are under manual control. Further, the very low governed speed is of material advantage in fishing jobs which generally must be carried on slowly and carefully.

Another oil-field application is that to pipe-line pumps. These units usually consist of a high-pressure plunger pump belted or chain driven from the Diesel crankshaft. The entire unit is mounted on a skid framework and its portability particularly commends it. Frequent y a "wildcat" will be "brought in" at a distance from a developed field at a point where no facilities exist for disposal of the oil. It is a simple matter to move one of these units to the well and dispose of the oil. One unit for this purpose consists of a 92-hp., 4-cylinder, solid-injection Diesel belted to a 2-cylinder, 700-lb.-per-sq.-in. pump.

IRRIGATION

In irrigation a recent installation of an 800-r.p.m., 30-hp. Diesel direct-connected to a 3150-g.p.m. centrifugal pump under 20 ft. head is part of a complete Diesel installation in Montana which has changed a losing proposition into a paying one. All costs here, including maintenance, depreciation, repairs, will not exceed $2 per acre per year, a very low cost for irrigation.

Another application in the irrigation field should be noted in the deep-well pumps direct-connected to the engine. In this field the usual factors of preference apply forcibly—lower freight, less foundation expense, and less installation labor. Low-speed Diesels have long been used. They usually have been belted types, the belt being given a quarter-turn from engine to pump rotor. The introduction of the high-speed Diesel has been effected with the addition of a bevel-gear speed changer, in one

case a ratio of 1.6 being employed. This is an example of the necessity confronting the manufacturers in this field of developing auxiliary units to make more practical and convenient the application of the high-speed Diesel. Fig. 3 shows a typical application similar to that on the Carl Schroeder rice farm near Stuttgart, Arkansas. It is a 60-hp., 718-r.p.m. engine, and is direct-connected to a 14-in. five-stage turbine pump set 100 ft. below the surface. The total lift is 123 ft. and 917 g.p.m. are delivered. The pump speed is 1147 r.p.m. and the fuel consumption $3^1/_3$

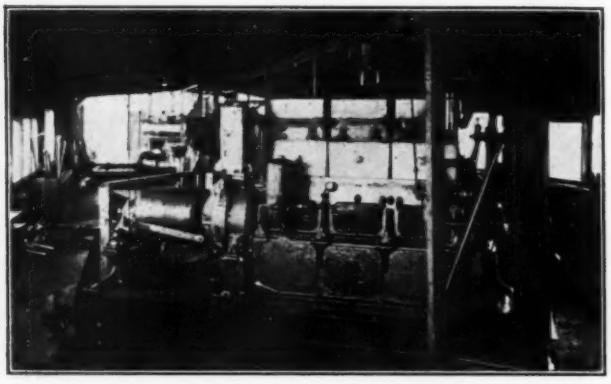


FIG. 4 6-CYLINDER, 180-HP., 1000-R.P.M. UNIT OF TYPE USED ON DREDGE, MCHENRY, ILL.

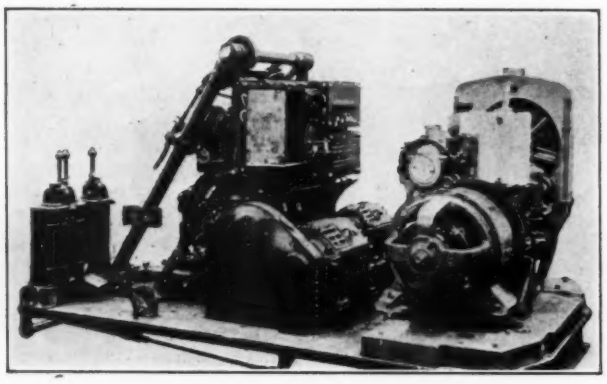


FIG. 5 MACHINERY ARRANGEMENT OF A $1^1/_4$-CU. YD. DIESEL-POWERED ELECTRIC-TRANSMISSION SHOVEL EXCAVATOR

gal. per hr. The horsepower developed is between 45 and 50, making the fuel consumption about 0.5 lb. per hp-hr.

Another similar installation is that on the rice farm of J. J. Miller near Stuttgart, Arkansas. This is also a 60-hp. high-speed Diesel direct-connected through a bevel-gear drive. The pump is 100 ft. below the surface and delivers 1075 g.p.m. This pump waters 240 acres of rice land at a seasonal cost of $450 for fuel and lubricating oil, or less than $2 per acre. This operation was formerly done by electric motors at a cost of $33 per day for current as against $5.15 for fuel and lubricating oils for the Diesel. The pumping season is about 80 days, so that per season the saving is more than $2000. The installation will pay for itself long before replacement is necessary. Another installation is at Roswell, New Mexico, on the property of Southspring Ranch and Cattle Co. This is a 90-hp. unit direct-connected to a 15-in. turbine pump. This unit delivers 3400 gal. per min. against a total lift of 45 ft. and uses $4^1/_2$ gal. of 30 to 32-deg. B. fuel oil and 0.1 gal. of lubricating oil per hour.

MARINE

In the marine field, the *N.P.1.* at Norfo k, Virginia, is a police patrol boat of 54 ft. length, 12 ft. beam, and $3^1/_2$ ft. draft. It is powered by a 92-hp., 850-r.p.m. Diesel and uses $4^1/_2$ to 5 gal. per hour of 28 to 30-deg. B. fuel costing $4^1/_2$ cents per gal. Using a 28-in. × 28-in. screw at 775 r.p.m. it maintains a speed of 12 knots. With a 30-in. × 19-in. screw at 850 r.p.m. it is able to maintain the same speed.

AIR COMPRESSORS

An interesting application is that of a high-speed Diesel to a portable air compressor. A prominent compressor company has had one of these in commercial service for several months. It is a 320-cu. ft. compressor powered by a 92-hp., 4-cylinder, 6-in. × 8-in., 1000-r.p.m. Diesel. The company, however, is operating it at 850 r.p.m.

An interesting application of a high-speed Diesel consists of a 92-hp., 1000-r.p.m. Diesel, 4-cylinder, 6-in. × 8-in., belted to a 16-in. × 10-in. × 14-in. air compressor, delivering 400 cu. ft. of free air per minute against 130 lb. pressure. The fuel oil used is 28 to 30 deg. B., and the fuel consumption varies from 0.4 to 0.45 lb. per b.hp-hr.

There have been numerous applications of low-speed Diesels to dredge service. So far as the author has been able to discover, there is only one dredge in operation with a high-speed Diesel. This is the dredge of Julius Keg, McHenry, Illinois (Fig. 4), which is a belted installation. The engine is a 6-cylinder, 180-hp., $6^1/_2$-in. × $8^3/_4$-in., 1000-r.p.m. Diesel governed at 900 r.p.m., and is 49 in. wide, 139 in. long, and 89 in. high over the radiator. It is now in 24-hour service on the Fox River in Illinois. It drives a 10-in. American Manganese pump weighing 12,700 lb. The pulley is 18 in. in diameter and has a 22-in. face.

LAND-BORNE EXCAVATING MACHINERY

In the excavating-machinery field there have been several commercial applications, and several others are about ready to be announced.

There are three methods in general use for transforming the power of the Diesel into useful work at the bucket tooth. One of these is by the use of direct mechanical drives through chains and gears, reversal of the motions being effected by means of clutches and overloads being cared for through slippage of the latter. A second method involves the combination of the Diesel, an air compressor, and a mechanical drive to one of the three major motions necessary to power-shovel service, namely, hoist, swing, and crowd. The air compressor supplies air to the storage tanks. From these it passes through a heater and has its temperature raised to about 400 deg. fahr. by the exhaust gases from the Diesel, and thence to the engine used for turning the rotating frame about a vertical axis, known as the swing or rotating engine, and to the engine used for forcing the bucket into the material being excavated, known as the crowd or thrust engine. The motion which lifts the bucket up through the material and fills it is the hoist motion, and this is chain driven direct from the Diesel crankshaft.

The third method direct-connects a direct-current generator to the Diesel and by means of differentially wound generator fields and other specially devised control circuits secures from the associated motors speed-torque characteristics closely approximating the steam-engine speed-torque characteristic except at very low speeds, where the torque of the Diesel-electric combination is decidedly better than that of the steam engine (Fig. 5). Here there are three d-c. motors, usually series-wound in the sizes under consideration, one each for the hoist, swing, and crowd motions. Vertical-handle controllers mounted in the same relative positions as and operated in much the same way as steam-excavator levers make handling both simple and easy of learning by the operator.

From the standpoint of operating characteristics, steam has always been and still is the ideal to which excavating-machine designers look. The quality most uniformly commended is the ability of the ungoverned, throttle-controlled steam engine to give a uniformly rising torque with decreased speed—the "tugging" trait, the ability to pry out obstructions. A glance at the graph (Fig. 6) will reveal how far from the ideal the carburetor engine is and how much better the Diesel is—the torque increase at lower speed being nearly 30 per cent for the same size of engine. Also a lower final speed (before stalling) may be availed of with the Diesel.

A further study of the graph will also show the manner in which the shovel designer has availed himself of the fine torque characteristic of the high-speed Diesel in combination with the added flexibility in design of the electrical transmission to effect a speed-torque characteristic very closely approaching the ideal steam characteristic. For in power-excavator service, through a part of the speed range the importance of power is predominant, but through another portion torque governs. The designer must in some way meet both of these requirements in order to make an excavator which will be profitable in service, and therefore satisfactory to the purchaser.

Fuel costs of less than a cent per cubic yard have been found to be common on Diesel-powered excavators by a prominent company building this class of equipment. Since the gas engine "breaks" at about 50 per cent normal speed, while the Diesel "hangs on" to about 30 per cent, outputs are about 10 to 15 per cent higher with the Diesel than with the gas engine. The fuel is about half in quantity, and the fuel costs are therefore from $^1/_8$ to $^1/_{10}$, as the price variation per unit is 4 or 5. An estimate of costs recently published by this company, shows for a 1-cu. yd. machine in a 200-day operating year a saving of $2230 over a gasoline-operated machine of the same size, interest and depreciation being properly accounted for.

On a real-estate development 25 miles east of Cleveland, Ohio, a Diesel-air dragline excavator, equipped with a 1-cu. yd. dragline bucket and handling comparatively easy digging, consisting largely of black alluvial dirt, and working steadily, since the work consisted of building a dike—which means that there was no waiting for trucks—used from 20 to 25 gal. of fuel oil at $8^1/_4$ cents per gal. for each full 10-hour shift. The average cost for fuel oil, lubricating oil, and grease was about 25 to $27^1/_2$ cents per hour.

General Cost Data

A rather extended experience of one of the prominent manufacturers of high-speed Diesels indicates the following as conservative figures for use in cost estimating:

Depreciation	7 to 10 per cent of original cost, annually
Maintenance and repairs	0.05 cent per rated b.hp-hr.
Taxes and insurance	2 per cent annually
Interest	5 to 7 per cent annually
Fuel per b.hp-hr.	0.42 to 0.6 lb.[3]
Lubricating oil	0.0005 gal. per hp-hr.

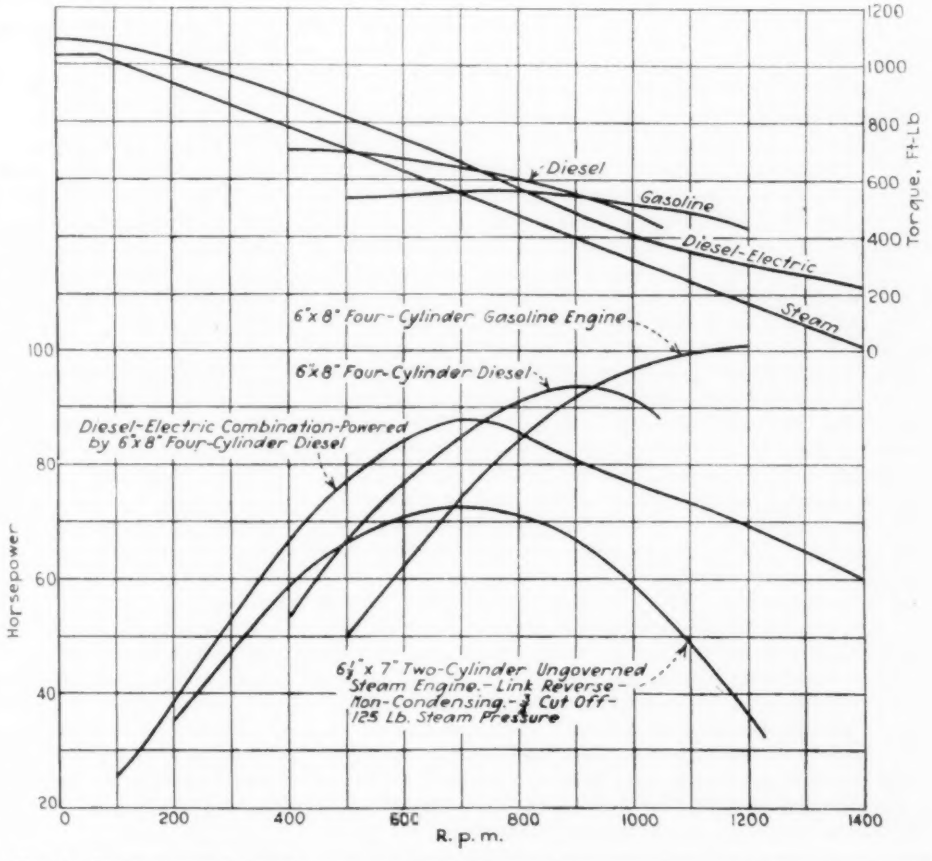


FIG. 6 COMPARATIVE SPEED-TORQUE AND SPEED-POWER CHARACTERISTICS OF DIESEL, GASOLINE, DIESEL-ELECTRIC, AND STEAM-DRIVEN EXCAVATING MACHINES

Medium-Speed Applications

There are numerous applications in the area between low speed and high speed where there is a doubt as to the class in which they should fall. There is the rail car of the New York Central which has a 200-hp., 8-cylinder "V"-type, 8-in. × $9^1/_2$-in. engine, operating at 550 r.p.m. and making about $3^1/_2$ miles per gallon of oil or about 0.02 cent per ton-mile. This car weighs about 105 tons fully loaded and is capable of 60 m.p.h.

There is the 300-hp. Lehigh Valley low-speed switching engine which has a 12-cylinder "V"-type, 550-r.p.m., 8-in. × $9^1/_2$-in. Diesel having air injection. This unit is direct-coupled to a 195-kw., 700-volt, d-c. generator. It is claimed that the speed-torque characteristics of this combination are even better than those of a steam locomotive, while fuel costs are one-fourth to one-sixth those of the steam. The fuel-oil consumption has been found to be 0.48 lb. per b.hp-hr., using 19,500-B.t.u. fuel oil. At full load about 20 gal. per hour are consumed. One gallon of lubricating oil is sufficient for 24 hours of full-load duty.

[3] Depending on various factors, such as percentage of time under full load.

Maintenance and Repair of Marine Diesel Engines

Maintenance Repairs—Repairs Required Because of Faulty Design—Repairs Necessitated by Accident, Stress of Weather, or Other Unusual Conditions—Nature of Repairs Most Commonly Required

By LOUIS R. FORD,[1] BROOKLYN, N. Y.

BEWILDERINGLY rapid progress has been made during the past ten years in the development of the marine Diesel engine, and the extent of its application, in various forms, to the propulsion of ships is probably difficult of realization by those who do not make frequent contact with shipping. Today there is practically no type of self-propelled vessel in which Diesel engines have not been installed or for which such installation has not been planned.

It was only a short time ago that general opinion had the limits of the field of application of the marine Diesel engine definitely defined. The upper limit was the comparatively slow cargo boat of 10,000 to 12,000 tons deadweight, requiring not more than 3000 shaft horsepower. Beyond that limit the field was exclusively that of steam, applied through either reciprocating engines or turbines. The lower limit was the heavy workboat, in which a very heavy, slow-turning Diesel of not less than 150 s.hp. could be used. Below that the only alternative was the light, high-speed gasoline engine. After this fairly sharp delimitation was all nicely arranged, the situation was thrown into some confusion in 1925 by the placing in service of the M.S. *Aorangi*, a palatial passenger liner of 17,491 tons, fitted with four Diesel engines developing a total of 13,000 s.hp. that gave the vessel a sustained speed of 17 knots.

This vessel was an unqualified success and it was rapidly followed by larger and more powerful passenger liners. The *Saturnia* and *Vulcania*, operating on regular schedule out of New York are equipped with supercharged, double-acting Diesel engines capable of developing 24,000 s.hp. The upper limit in the marine field seems to have been removed entirely by the serious consideration that is now being given by the White Star Line to the proposal to install Diesel drive in its new passenger liner *Oceanic*, the largest in the world, now under construction.

The situation that exists today is that a majority of the new ocean-going commercial vessels being built throughout the world are Diesel-engine driven. Harbor craft, such as tugs and workboats, are being motorized in increasing numbers, and so completely has the Diesel engine been accepted as the standard type of drive for pleasure yachts, that in new construction the steam yacht is almost an oddity.

It is not the intention here to convey the impression that the steam-propelled vessel is obsolete or that the steam-engine and boiler manufacturers are preparing to close up their shops. As a matter of fact, the great majority of the world's ships are steam driven, and the advancements in steam engineering, such as the use of increasingly higher boiler pressures, that have resulted from the competition of the Diesel engine are giving steamships that are decidedly competitive, economically, with the best motorships.

[1] United Dry Docks, Inc., New York, N. Y.

Presented at the Second National Meeting of the A.S.M.E. Oil and Gas Power Division, State College, Pa., June 24 to 27, 1929. Abridged.

NOTE: Statements and opinions advanced in papers are to be understood as individual expressions of their authors, and not those of the Society.

The great increase in the number of Diesel-engine-driven vessels has, however, become an important factor in the business of the ship repair yards, where it has had a profound influence modifying old and stimulating the development of new method and procedure. Maintenance and repair of ships and their machinery is essentially a shipyard function, because the watch-keeping requirements and lack of adequate facilities on board ship limit the engine-room personnel to comparatively minor maintenance work. The ship repair yard, then, offers a very good point of contact where accurate and comprehensive information regarding structural details, operative requirements, and comparative performance of miscellaneous designs can be obtained.

Experience has developed the fact that for work on the marine Diesel engine, especially for fitting up and assembly on board ship, machinists with rather special qualifications are required. The ordinary requirement, skill in mechanical work, should be supplemented by the thoroughness, patience, and dependability, as well as by some understanding of the fundamental differences in the nature and functions of the elements of the Diesel and steam plants.

The necessity for thoroughness arises from the fact that it is not practicable constantly to supervise the work of each individual, and is illustrated by an extensive repair job to a piston-cooling service recently executed by the author. In this case the brackets supporting the swinging pipes used for conveying cooling oil to and from the pistons were secured by studs with castellated nuts, the usual hole being provided in the stud for inserting a cotter pin. During assembly at the works of the builder the castellations on some of the nuts did not line up with the holes, and the nuts were backed off by a careless workman until the cotter pins could be inserted. This left several nuts loose, and during operation of the engine at sea the brackets carried away, causing the heavy swinging arms to smash things up pretty badly before the engine could be stopped. Aside from the possibilities of breakage such as this, lack of thoroughness may necessitate some very expensive work to correct some very minor defect that is buried in the accessory structure of the engine.

During the recent installation of a new engine, a preliminary test of air lines after erection disclosed a leak at the junction of the high-stage compressor discharge pipe and the aftercooler coil. Investigation disclosed that the small color on the end of the copper pipe of which the coil was formed was brazed only on one side. The actual brazing needed to correct this defect required only about 30 min. in the shop, but so much of the engine structure had to be dismantled to get the coil out that it required four men working three days to remove and replace it.

Most shipyard work is done on a contract basis, with the time and price agreed upon in advance, and failure to complete the work within the agreed time usually involves a heavy demurrage charge against the yard. The preparation of cost estimates is a very important function of the shipyard organization, and in the case of the motorship it involves difficulties not associated with the usual steamship work.

The construction of the steam engine, the steam boiler, and the steam turbine and their arrangement in ships are standardized sufficiently to permit standardizing many repair operations on them, and reducing to a standardized basis the cost estimating for these operations. A simple formula can be developed for determining the cost of reboring a cylinder on a steam engine, and the cost of many other operations on steamship machinery can be estimated from dimensional data without actually surveying the ship.

A different situation exists when considering repairs to motorship machinery. Here we find a most troublesome lack of finality or permanence in design. To the repair man, it appears that no Diesel-engine design ever stays put. It is seldom that even sister ships, built to one order by the same builder, have machinery that is exactly alike in every detail. An example of this is a crankshaft job carried out by the author. The coupling bolt holes in the crankshaft of a 5000-hp. engine had to be reamed and new bolts, about 4 in. in diameter, fitted. A special set of reamers and a special machine to drive them were manufactured. Shortly afterward the engine of a sister ship, apparently a duplicate of the first, required the same job, but after the work was started it was found that the couplings on the second engine, instead of having straight holes as had the first one, were fitted with tapered bolts. This necessitated the manufacture of a second set of special reamers at a cost of about $200.

Such variations in details of construction or arrangement of parts often have a legitimate reason, resulting from the unusually rapid advance in the art of Diesel-engine design or from experience with similar engines in service, but just as often it represents the yearning to express individuality that every designer seems to feel. Even in the case of engines built under license agreement, the licensee usually introduces a large number of changes in design of minor parts. For example, it is hardly safe to base estimates for repairs to a British-built Burmeister & Wain engine on drawings obtained from the original designers in Denmark. Fuel valves and fuel pumps seem to be the objects of the greatest amount of study and more or less ingenious rearrangement. The basic functions of all fuel-injection valves are the same and there is a fundamental similarity in the construction of all of them, but the multitude of variations in details is astonishing.

The net effect of this general lack of uniformity in Diesel-engine construction, from the estimator's point of view, is to increase the hazards of cost estimating. If such estimating is to be done intelligently so that the motorship owner will receive the benefit of low repair costs and the shipyard have reasonable assurance against loss, it is essential that specialized knowledge of past and current Diesel-engine design and construction be available to the estimators.

Motorship repairs, in general, may be grouped into three classes as follows: (1) maintenance repairs, or those resulting from ordinary wear and tear in service; (2) repairs required as a result of faulty design, or changes due to improvement in design; and (3) repairs required as a result of accident, stress of weather, or other unusual conditions. To these might be added another classification less clearly defined, namely, unnecessary repairs—unnecessary in the sense that the need for them arises from preventable causes. One of the most common sort of jobs in this latter class is the repair or replacement of cylinder heads, liners, and pistons that have cracked as a result of accumulation of scale and sediment in the cooling-water spaces.

Experience with many cases has convinced the author that keeping the water sides of heat-transmitting parts free from insulating deposits of scale, sediment, grease, and rust does not receive the attention it deserves from either engine builders or engine users. Periodical and thorough cleaning of all water jackets, whether the cooling water be fresh or salt, should be just as much of a routine procedure on the motorship as periodical boiler cleaning is on the steamship. In fact, the whole subject of what may be termed "preventive treatment" should receive more attention than it does. Warning as to the necessity for careful attention to lubrication may seem to partake of redundancy, yet a surprisingly large part of repair-yard work on Diesel engines consists of renewals of small pins and bushings that become worn as a result of inadequate lubrication.

Engine builders have done much and can do more in the way of making special provisions to facilitate inspection, cleaning, and other preventive measures, but something else is needed. It would seem that the interests of the engine builders would be well served if they went a step farther and prepared detailed schedules of routine inspections and overhaul, schedules of operating conditions to be maintained, supplied any special tools and instruments required by these schedules, and, finally, insisted that such schedules and facilities be used.

The nature of the repairs most commonly required in the three general classes previously listed, the character of some defects developed, and some of the unusual or unexpected conditions that arise in service may best be brought out by considering in turn each of the principal engine elements.

BEDPLATES

Most bedplate troubles arise from the surprising flexibility of what is usually a massive structure of cast iron. An example of this was the bed of a 500-hp. engine that had been carefully reset to correct an original misalignment. After accurate alignment was complete and the bed were resting on permanent steel chocks, the spaces between chocks was closed with wooden filler pieces, as is the usual custom in marine work. It was found that too thick a filler piece driven under the bed at about its center with an ordinary hand hammer bowed up the bed enough to throw the coupling on the end of the crankshaft measurably out of line.

On three different Diesel-driven generator sets the armature shafts broke in service, and when dismantled it was found that the end of the bed supporting the outboard generator bearing was in each case bent upward nearly $^3/_8$ in. The holding-down bolts simply pulled the bed down to conform to the heights of the chocks, which were not lined up accurately.

On another vessel a broken crankshaft was found to be due to misalignment caused by bending of the engine bed when a certain disposition of cargo caused the ship's hull to deflect in the way of the engine room.

FRAMING

Frames are subject to the same sort of deflection as the bed, and in many cases this deflection is caused by bending of the bed. Fig. 1 shows an arrangement used in one type of engine where two adjacent frames are joined by a heavy, box-section, fore-and-aft girder about four feet above the bed, this girder being utilized to support a walking beam for operating several pumps. When replacing one of these girders that had cracked in service, great care was exercised to machine the faces of the flanges accurately so that the member, about five feet long, would be a snug fit between flanges on the frames. After it was in place and bolted at one end, a maximum clearance of 0.010 in. was found between flanges at the other end. Before the final bolting up was done some 500 tons of cargo had been loaded into the forehold, and a final measurement showed the clearance to have increased to 0.059 in. due to spreading apart of the frames.

CYLINDERS

Cylinders, or what may more precisely be termed cylinder jackets, give very little trouble, although on some of the older

engines an occasional cracked cylinder will be found. Cylinder liners, however, are a prolific source of work for the repair yard. Liner casualties occur either from wear or cracks. Wear is a normal result of engine use, but it sometimes assumes abnormal proportions if operating conditions are not right. What appears to be the most important factor is the fuel used. Some fuel will contain more abrasive impurities than others, but it is the author's belief that all fuel oil, even the highest commercial grades, should be passed through a centrifuge before being used in the engine. An example of the value of the centrifuge is the case of two sister ships of 2000 hp. attended by the author. After a trip around the world, both using the same kind of fuel, it was found that

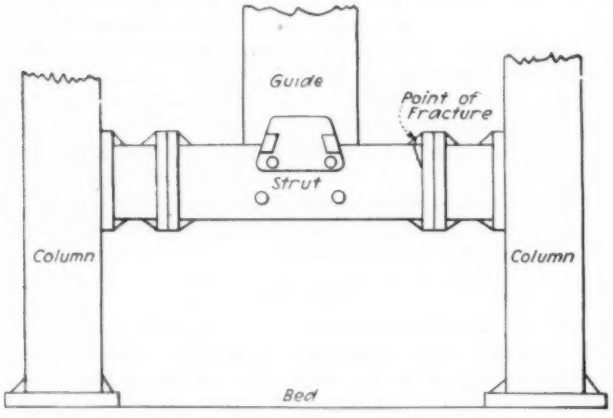


FIG. 1 CRACKED GIRDER BETWEEN FRAMES

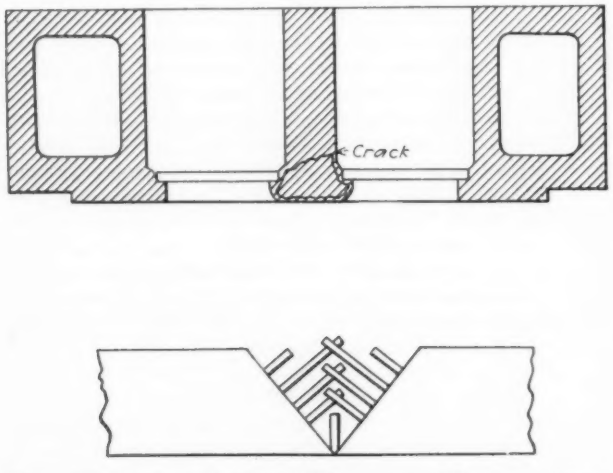


FIG. 2 PREPARING CYLINDER HEAD FOR WELDING. ABOVE, LOCATION OF CRACK; BELOW, V-CUT AND ARRANGEMENT OF STUDS

liner wear amounting in one cylinder to 0.270 in. had occurred in one vessel, necessitating the renewal of that liner, while in the sister ship the maximum liner wear observed was 0.025 in. The difference is accounted for by the fact that in the first ship the fuel, which was very dirty, had been, during a portion of the voyage, used directly from the tanks, while in the second no fuel was used without centrifuging.

Various estimates have been made as to what should be considered normal length of life for a liner, and although there is wide divergence of opinion, experience seems to indicate five years as the average.

A troublesome feature of liner removal is the sticking of liners in the jackets, especially in two-cycle engines. Liners that are originally fitted so that they will drop into place in the jackets with little or no pressure, sometimes require from 200 to 300 tons of hydraulic pressure to remove them. This is caused by the carbon or scale accumulation that gets into the seating. After this sealing deposit is once broken, no great pressure is required to move the liner the rest of the way.

Cracked liners are encountered occasionally, but in practically every case cracking is due to no fault in the liner itself. It usually results from piston seizure, and such seizure usually results from inadequate cooling of the piston. No attempt is ever made to repair cracked liners, renewal being the only remedy.

CYLINDER HEADS

The head is usually the most complicated casting on the engine, and as such suffers most from heat troubles. The usual head repair is welding of cracks. Both oxyacetylene and electric welding are used, but the former is preferred if the location of the crack will permit its use. If the crack is near the outer edge of the head, where expansion and contraction stresses can be accommodated, the gas welding can be used, but if the crack is near the center of the head or surrounded by unsymmetrical masses of metal, as is usually the case, electric welding must be resorted to. To make a successful head repair, electric welding must be done very skilfully and studding employed. Fig. 2 illustrates the method used where the crack was through the bridge between fuel-valve and exhaust-valve openings. After a wide V had been cut to the bottom of the crack, holes were drilled and tapped for steel studs so that the studs interlaced as shown. The upper studs were then removed to give access to the bottom of the V, and welding in of the new metal was started. As the V filled up, the upper studs were added, so that all studs were completely embedded in the completed weld. Where a weld crosses a valve-housing seat, as was the case with this one, great difficulty is experienced in machining the seat accurately, due to the cutting tool's springing when it strikes the junction between new and old metal. This difficulty has been met by the use of tungsten carbide tools, which cut the hard metal with ease.

CRANKSHAFTS

Breakage of crankshafts at the present time is very unusual. Most repair work on crankshafts consists of refinishing pins and bearings that have become scored or worn, or correcting alignment of the shaft in its bearings. Whenever it is necessary to renew a broken shaft, it is found that breakage is due to misalignment or torsional vibration. Wear of main bearings is more rapid in marine engines than in land engines. The more flexible nature of the structure on which the engine rests, as compared to the mass of concrete under the land engine, makes it more difficult to maintain a continuously unbroken oil film between shaft and bearing box.

Torsional vibration is a much less common source of trouble than in former years, but it is found occasionally. An interesting case demonstrating the destructive effects of torsional vibration is that of the crankshafts previously mentioned as requiring reaming of the coupling-bolt holes. This occurred on a group of ships having crankshafts about 20 in. in diameter, in turning 87 r.p.m. There was no noticeable evidence of vibration while the engines were running, yet the coupling bolts became loose or broke, and the coupling faces were deeply scored and worn. In this case it was possible to correct the trouble by changing the firing order of the cylinders and the relative positions of the cranks.

Fig. 3 shows the effect of misalignment. This shaft broke while the vessel was in southern waters and a stop was made in a small Central American port to make a temporary repair to enable the vessel to reach New York. When the shaft was removed it was found that the main bearings were badly out of

line, one being so low that the shaft did not touch it, even when deflected by load. In connection with the subject of crankshaft alignment, it is worthy of note that provision for easy removal of bottom shells of main bearings is important as a factor in reducing cost of repairs. The author had occasion to adjust the bearings on one large engine in which the bottom halves were made rectangular and fitted into rectangular recesses in the main-bearing girders, with projecting flanges to prevent end movement. To get a bottom half out it was necessary to dismantle the rods and lift the 15-ton crankshaft vertically 15 in. To

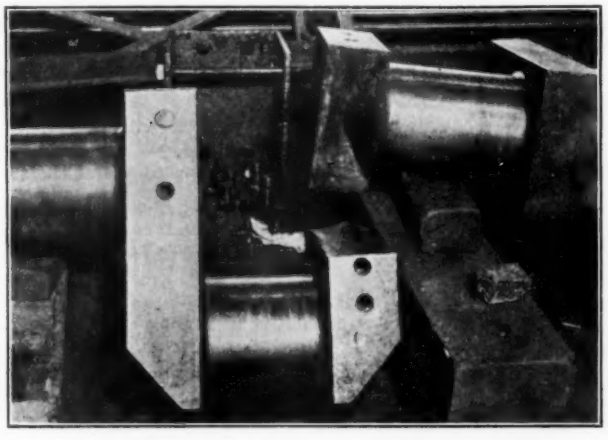


FIG. 3 CRANKSHAFT BREAK DUE TO MISALIGNMENT

permit this much vertical lift the spray-air-compressor housing had to be disconnected and lifted off the bed.

CONNECTING RODS AND CROSSHEADS

Connecting-rod repairs are so infrequently required that they may be dismissed without discussion. Crosshead trouble is normally confined to slipper wear, but there are occasional exceptions that are of interest. Several instances of crosshead failure have occurred, but it is worthy of note that one type of engine in which these breakages occurred has been practically removed from the market, while another type has been fitted with a new design of crosshead that has given no trouble. One rather large repair to a crosshead guide on a 5000-hp. engine was required after the crosshead slipper wedged in its guide and cracked the supporting housing. The shapes of slipper and guide are shown by the sketch in Fig. 4. During some routine overhaul by the ship's engineers, the piston rod of this particular cylinder was disconnected from the crosshead and the engine turned with the jacking gear. The ship was trimmed by the stern and the slipper had clearance enough to permit it to drop to one side, slightly out of normal alignment. When it moved upward, the triangular corner wedged in the guide and cracked the housing.

PISTON RODS

Piston-rod troubles may be said to be non-existent in single-acting engines that have such rods, but in the newer double-acting designs piston-rod breakage has been rather common. These breakages have resulted from both incorrect design and improper material, but in all the cases that have come to the author's attention the original defects have been removed, and there is no reason to believe that piston-rod breakage need, in the future, be regarded as a feature of double-acting engines. Experience with such materials had demonstrated that for piston-rod manufacture it is not wise to use alloy steels of a type, the physical properties of which cannot be accurately controlled and on which the effects of heat treatment cannot be accurately predicted.

A factor in piston-rod maintenance that is confined to the double-acting type is wear of the rod by the packing in the lower head. An apparently successful experiment has been made by plating the rods with chromium in one make of engine. A comparison of these rods, made after a voyage of about 28,000 miles, with unplated rods in another engine of approximately the same size showed considerably more wear of the latter.

PISTONS

From the repairman's point of view, the piston seems to be the most troublesome of all the major parts of the Diesel engine. The trouble encountered is usually cracking, or wear of ring slots. There are two ways in which cracking occurs: approximately radial cracks develop in the crown, or circumferential cracks in the side or skirt. The first is the more common kind, and the appearance of the cracks indicates that it is associated with the phenomenon of metal growth by repeated heating. The second type of fracture, cracks in the sides, is almost invariably due to

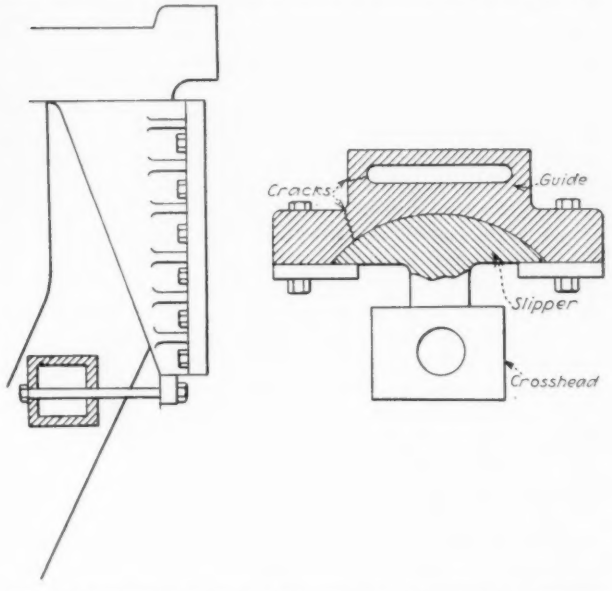


FIG. 4 CROSSHEAD GUIDE CRACKED BY JAMMING OF SLIPPER

piston seizure in the liner and is usually associated with cooling-system failure. Welding procedure has been developed to the point where most cracked pistons can be salvaged at a cost substantially less than the price of a new one.

As in the case of cylinder heads, either gas or electric welding can be used, but the former is much to be preferred. It can be used successfully, however, only when the piston can be preheated. The procedure is as follows: All burned metal in the vicinity of the cracks is cut away by drilling, then an air chisel is used to cut a wide V along the line of each crack. In each case the V must extend the full length and depth of the crack. If the crack goes clear through, the tip of the V must just penetrate the inner face of the metal. If a furnace large enough to take the piston is available it can be used for heating, but otherwise a simple furnace can be made by building up a checkered wall of firebrick surrounding the piston, then wrapping asbestos paper around the wall, leaving a draft opening at the bottom. A sheet of asbestos board is laid over the top, with a small opening left for draft. A charcoal fire is used to heat the piston up slowly and evenly to a cherry red, then the welding operation is started through a small opening in the asbestos directly over the spot to be welded. Usually two welders working alternately are required because of the great heat. After the V's have been

filled up carefully and the new metal consolidated with the old, all openings in the asbestos are covered up to keep the cold air out and the fire is allowed to die out. The piston should not be removed until it is cool enough to handle.

The metal growth that occurs as a result of heating is sometimes surprisingly great, but will vary with the quality of iron in the piston. In one case a set of trunk-type pistons 20 in. in diameter increased as much as $^3/_{32}$ in. in diameter during the welding process. It is also interesting to note that in the case of this particular set of pistons the diameters of the piston-pin holes increased so much that it was necessary to bore them out and put in bushings to receive the pins. On later pistons of the same type it was found practicable to prevent this enlargement of the piston-pin hole by applying heat only to the portion of the piston above the hole, using four oil torches arranged symmetrically around the piston.

In connection with the occurrence of heat cracks in the center of the piston crown, it was found that such cracks could be prevented in one type of piston by cutting a circular groove in the crown, as shown in Fig. 5. The increasing use of forged-steel pistons seems to have increased the proportion of ring-slot jobs. Wear of ring grooves is particularly rapid when the cylinder liner is badly worn. Liner wear is never uniform throughout the length of the cylinder bore, and as the piston travels back and forth a "breathing" effect is produced on the rings by the varying diameter of the bore that tends to wear away the side walls of the ring grooves. Pistons worn in this way can be repaired by truing up the grooves in a lathe and fitting oversize rings, but if it is desired to retain standard-size rings the walls of the slots are cut back and then built up by welding, after which they can be machined to original dimensions. A recently patented scheme is to provide a wearing ring locked into each groove, so that the wear occurs on these rings instead of the piston.

On one ship that came in for repairs, one piston was found with all of the studs joining the piston to the piston-rod flange broken. Since the piston remained on the rod it is obvious that no gas load or inertia load could have broken the studs, and it was concluded that breakage was caused by distortion of the pistons when heated. The original studs were replaced by longer ones, with sleeves under the nuts, and no more breakage occurred.

The exhaust valve is the one most frequently in need of repair due to the fact that a leak usually results in a burned-out valve or seat. A type of valve frequently dealt with is shown in Fig. 6. Here provision has been made for renewing the seat by making it separate from the valve and holding it in place with the threaded ring. It is usually necessary to cut these rings off as they burn fast to the stem in service. Fuel valves come next to exhaust valves in the amount of repairs required from sources outside the ship. The most common of these repairs is the renewal of needles.

Cooling System—Fuel Pumps

Cooling-system troubles generally arise from two causes: deposit of dirt, oil, or scale from the water, and corrosion. In nearly every case where an engine has been opened up for cleaning and large collections of dirt or scale have been found at any particular points, study of the structural arrangement will show that there is stagnation or retarded flow at those points.

In numerous cases the advantages of fresh-water cooling have been nullified by extensive deposits of oil that gain access to the cooling system. In the case of one large engine that had suffered from scale deposited by salt cooling water, the entire cooling system was changed over to fresh water. After one voyage the ship returned for examination and the entire cooling system was found to be heavily coated with oil. Investigation disclosed the source of this oil contamination to be the plunger of the water-circulating pump. This was a beam-operated pump enclosed within an extension of the crankcase enclosure where it was exposed to the heavy lubricating-oil mist.

In some quarters the impression seems to prevail that if distilled fresh water is used for cooling no corrosion troubles will be experienced, yet repeatedly jobs come in that show the fresh cooling water to be very actively corrosive. A case in point is the internal pipes placed inside the piston rods of double-acting engines to convey cooling water to the pistons. On one make of engine repeated piston seizures were experienced before it was found that these internal pipes had corroded away, although fresh water was used. These pipes are now made of stainless steel. It has been found that if the system for circulating fresh water includes any open point, such as open discharge funnels, where active churning of the water produces aeration, the corrosive effect throughout the system is increased. The operator of any Diesel engine using fresh water for cooling can well take a leaf from the book of the steam-boiler operator and use the

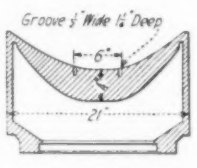


FIG. 5 METHOD OF GROOVING PISTON CROWN TO PREVENT CRACKING

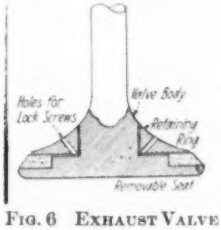


FIG. 6 EXHAUST VALVE WITH REMOVABLE SEAT

same precautions to keep the water non-corrosive as are used for conditioning boiler feedwater.

The usual sort of repair needed by fuel pumps is the grinding down or renewal of plungers, and, occasionally, the manufacture of new valves. It is found that packed plungers require more attention than packingless or lapped plungers. The packing is usually set up so tight to prevent leakage that it wears the case-hardened plungers very rapidly. The success of the chromium-plated rods previously mentioned suggests the possibility of reducing this wear by the use of chromium-plated plungers.

In conclusion, it seems fitting to consider the much discussed but never settled question of relative cost of Diesel-engine repairs and steam-engine repairs.

The individual items of repair to the Diesel plant and steam plant are none of them sufficiently alike to permit comparisons of cost on a repair-item basis. The most accurate method of comparison is by means of the annual repair bills of two exactly similar vessels, one steam and one Diesel, operating on the same route and handling the same cargo.

It is the author's opinion, based on a number of years' experience in ship-repair work, that when operating under similar conditions, with equally competent engineers, the Diesel plant requires less repair than the steam plant but the repairs that are required cost more. An important difference in the two types of machinery is that a broken or worn-out part of a steam engine or boiler can be replaced at the majority of ports in the world, utilizing the local facilities at those ports, whereas a replacement part for the Diesel engine must be sent from the builder's plant or obtained from some other distant, especially equipped plant.

It would appear, then, to the thoughtful observer that when Diesel-engine design more nearly approaches a standardized basis and a certain measure of permanence succeeds the present kaleidoscopic variations in structural details, a more widespread development of repair facilities will be possible, less specialized knowledge will be required for operation, and general reduction in upkeep cost will result.

Aircraft for Passenger Transport

Seating Arrangements—Safety Belts and Parachutes—Vision and Lighting for Passengers—Heating and Ventilation—Noise and Vibration—Air Sickness—Comfort and Entertainment of Passengers—Comfort and Ease of Operation for Pilot

By CHARLES N. MONTEITH,[1] SEATTLE, WASH.

FOR those who have been actively concerned with aviation since it came into national prominence in 1917 with the declaration of war, or even as far back as the first flight by Orville Wright in 1903, there is nothing that has been more astonishing than the sudden awakening in the general public in the United States of a desire to travel by air. From an attitude that was decidedly apathetic, there was almost an overnight transformation to a display of keen interest. This change in attitude came of course in the spring and summer of 1927, following Colonel Lindbergh's flight to Paris. And, where formerly a common ground of conversation among travelers and men thrown together for a few idle hours was prohibition, the topic now is aviation and travel by air. In almost any group picked at random, one finds one or more business men who already are seasoned air travelers. In addition, they are generally enthusiastic in regard to air mail and air express, especially when they have experienced only infrequent delays in the service. This feature of public interest, having nothing to do with the transportation of passengers, will not be considered here, although it must be remembered that the best advertisement for the establishment of good-will in the business of carrying mail and express or any other type of commodity is a satisfied passenger who has made a trip over one or more air lines and has seen how they operate.

In Europe, regular passenger lines had been in operation for almost eight years prior to the establishment of similar lines in the United States, and those engaged in the design of equipment for the latter attempted to profit by the lessons learned in Europe. Many interested persons were able to go abroad and study the situation, recording their observations in technical memoranda and technical publications such as those issued by the National Advisory Committee for Aeronautics.

One of the most recent of such compilations of data is the third report issued by the Guggenheim Foundation in December, 1928. A study of this report brings out the fact that while such experience as has been obtained in the operation of passenger air lines in the United States agrees with that of the European lines, there are nevertheless a number of points upon which there are differences of opinion.

The items which will be discussed in this paper are as follows:

1. Arrangement of cabin
2. Safety belts and parachutes for passengers
3. Vision and lighting for passengers
4. Heating and ventilating
5. Noise and vibration
6. Air sickness
7. Comfort and amusement of passengers
8. Comfort and ease of operation for the pilot.

Comparisons with European comments on each subject, as set forth in the Guggenheim report, will be given wherever they are pertinent.

[1] Chief Engineer, Boeing Airplane Company.

Presented at the Third National Meeting of the A.S.M.E. Aeronautic Division, St. Louis, Mo., May 27 to 30, 1929.

NOTE: Statements and opinions advanced in papers are to be understood as individual expressions of their authors, and not those of the Society.

Arrangement of Cabin

The question of the size and arrangement of chairs, as well as provision for the passengers to move about at will within the cabin, must, in the preliminary design of an airplane for passenger transport, be considered with respect to the dimensions of the body, the weight of the chairs and other accessories, and the question of the balance, or trim, of the complete airplane. The Guggenheim report gives as the European ideal of passenger arrangement two rows of single chairs placed on either side of a central aisle. This has the extreme disadvantage of making the cabin very long for a given number of passengers provided they are given ample leg room, whereas the arrangement of two seats on one side of the aisle, with a single seat on the other, an arrangement which has made its appearance in the United States as well as in England and Germany, gives the advantage of concentrating the load in a fore-and-aft direction. It is also found that where a married couple are traveling together, such an arrangement tends to eliminate the feeling of isolation which timid air passengers experience when sitting by themselves. The single chair on the other side of the aisle is available for one desiring comparative isolation. It is true that such an arrangement necessitates a wider body, but, when the inside height of the cabin has to be sufficient to permit the average person to stand upright therein, this additional width is of little consequence, except that the fuselage frame and cabin flooring have to be somewhat heavier. Such an arrangement also permits the placing of the passengers closer to the center of gravity of the airplane, in which case the effects of rough weather will not be so pronounced. Further, the trim of the airplane is much more easily effected with such a concentration of the pay load. It is possible that eventually the arrangement used in the standard Pullman car will be employed, particularly if there are sleeping compartments to be provided. Some of Dr. Junkers' latest designs show the influence of the arrangements used in railway coaches.

The question of the size of the seats is rather an amusing one, particularly because the designers in the United States have had such widely different ideas on the subject. One cabin plane, advertised as being "luxurious," provides chairs which are a scant 14 in. wide. A 16-in. width is none too comfortable, and the French recommendation of 19 in. is certainly a step in the right direction. The ultimate aim is the comfort afforded by the chairs found in the Pullman parlor cars, except that the construction must be modified in the direction of lightness. Seats weighing more than 20 lb. are almost out of the question for the present-day airplane, and they should weigh even less than this. One design of reclining seat that has been made recently weighs only 13 lb. This chair is a trifle small, but affords ample comfort for all but extremely large persons. The reclining back is essential, since changing from the upright to a reclining position is the only relaxation permitted the passenger, except for an occasional walk up and down the aisle. This latter should not be encouraged, particularly if the airplane is traveling through rough air; for there is too much liability that the passenger in the aisle will be thrown off balance very violently, injuring, or at least discommoding, some other passenger or himself. As regards the aisle in the cabin, it is interesting to note that some of the operators in

Europe recommend a very narrow one to prevent the passengers from rushing aft in a real or imaginary emergency. A narrow aisle helps to solve the problem of providing seats of ample width without employing a cabin width which is all out of proportion.

One of the disadvantages of arranging passengers three abreast lies in the fact that the center passenger is afforded but a limited view of the scenery over which he is passing. However, for regular travelers over a given route this makes but little difference. Such an attitude is noticed on railroad trains; those making their first trip over a given route generally spend a large percentage of their time on the observation platform, while those to whom the trip is an old story spend their waking hours at a card table or in reading a book or magazine.

Looking into the future, it would appear that when we get larger power plants the passenger craft will become larger (it seems unlikely that future aircraft will have more than three or four power plants) and the arrangements will be similar to those found on the best railroad trains—there will be sleeping compartments, smoking rooms, an observation platform, and conveniences for serving meals. The limitations of the size of the craft that are used in regular service will be determined in some measure by the housing facilities that can be provided by the operators using them. There is also the consideration as to whether it will be more economical to operate one large airplane or several smaller ones. At the present time it appears that the arguments are all in favor of the use of several smaller units, but it must be remembered that the size of the units will be governed to a large extent by the comfort afforded the traveling public. Up to the present time little serious consideration has been given to the question of sleeping accommodations, but just as the railroads were forced to abandon the chair car for night travel, so will the air-line operators be forced to put into use aircraft that can provide comfortable beds for the passengers who wish to travel at night.

Under the heading of "arrangement of passengers" must be considered the disposal of their baggage and other parcel cargo which the plane may carry. Every one will agree with the European opinion that none but the lightest parcels should be in the passenger compartment. The heavy units of baggage should preferably be placed forward. There are several good reasons for this arrangement:

a The baggage will not come crashing into the passenger compartment in the event of an accident
b The forward compartment acts as a sort of shock absorber in the event of a crash
c The problem of balance of the airplane and consequently of the longitudinal stability is much simpler with such an arrangement.

One large transport now under construction is provided with a coat room in which heavy wraps may be hung properly when not in use, rather than be rolled into shapeless bundles and thrust into the light baggage racks in the cabin. The fewer things there are in the cabin that can be thrown about by rough air conditions, the greater will be the comfort of the passengers.

Safety Belts and Parachutes

This brings up immediately the question of safety belts and parachutes for the passengers. European and American practice are in agreement on the point of not providing parachutes. On a modern transport line there are generally but two occasions where a parachute would be of material benefit to the passenger: one is a major structural failure, and the other is fire. The check by the Department of Commerce on design should render structural failures improbable, if not eventually impossible, while careful study of the power-plant installation has made fire in the air a rare occurrence.

As for safety belts, British and Dutch opinion are against their installation. Most of the transports operating in the United States today do not provide belts for the passengers, but it is being demonstrated rapidly that they are sometimes very necessary. In some localities in this country smooth air is almost unknown, and in passing over these regions the passengers may be tossed about very badly unless anchored to their seats.

The pilot of a tri-motored transport on a well-known air line told the author that in one case his passengers were thrown out of their seats so violently as to wreck completely the light baggage racks overhead. In another instance an elderly lady was thrown from a seat in the rear of the cabin to the floor of the vestibule behind her. In one small cabin plane a single passenger was tossed about so violently as to be very painfully bruised, and at the end of the trip was found on the cabin floor in a dazed condition with the seat cushions piled on top of him.

Belts certainly should be provided, and while they need not be worn at all times, the steward should advise that they be used when the plane is known to be approaching a region of rough air or just prior to landing. The breakage of a wheel might cause a minor accident which would displace the passengers violently enough to cause injuries not necessarily serious but at least painful.

Vision and Lighting

Each passenger should have a window from which he can view the scenery and obtain light for reading, but which should be provided with suitable curtains to screen out brilliant sunlight. The windows should be as large as possible for two reasons: one is that the passenger should be given as much view as possible, and the other is that large windows can serve as emergency exits if necessary. On the other hand, there are two good reasons why the windows should be as small as possible: glass is heavy, and is not very efficient as a sound-proofing medium. The windows should be of non-shatterable plate glass and, in the size generally recommended in European practice (16×20 in.), should be approximately $^3/_{16}$ in. thick. Glass any thinner than this is very liable to accidental breakage by passengers.

In providing maximum of view for the passenger, one occasionally runs afoul of the old argument of monoplane versus biplane. After having been a passenger aboard both types of transports, the author is of the opinion that the obstruction to view offered by the lower wing of the biplane is more imaginary than real, particularly if the biplane is of the "one-and-a-half" type. Curiously enough, too, there seems to be a psychological effect in the sight of the struts and wires of biplane bracing. Passengers have expressed themselves as having a feeling of greater security when they can see two wings rigidly tied together.

With long flights at night, such as are now being made regularly in the United States (about 40 per cent of all flying done by the Boeing and Pacific Air Transport lines is night flying), means must be provided for lighting the cabins better than it is done by one or two dome lights in the ceiling. Each passenger's seat (or pair of seats if the two-and-one seating arrangement is used) should be provided with a shaded lamp with an individual switch. The lamps should be of sufficient power to permit reading without straining the eyes, and the shade should be adjustable to suit the passenger's convenience. (These latter features are some that are not as yet provided on most Pullman cars except the club and observation cars, although some of the later models are introducing more attractive and usable seat lamps.) It is of course necessary that all lamps in the cabin be controlled with a master switch under the pilot's hand. In flying in bad weather

or in making an approach for a landing, the pilots will prefer that all lights be extinguished for better visibility.

HEATING AND VENTILATING

One of the most interesting problems in the design of passenger aircraft and one that has not been solved in anything approaching a satisfactory manner by either European or American designers, is that of proper ventilation, properly controlled, for the cabin. There are certain fundamental things that such a system must provide if it is to be considered satisfactory. These are:

1 Open windows should not be depended upon for any degree of ventilation, because the blast of air entering the open window of an airplane cabin generally is entirely too strong to permit the passenger to enjoy it in comfort, even in the warmest weather. Then, too, the passenger who opens his particular window usually gives the full benefit of the stream of air to the passenger behind instead of himself. In extremely cold weather this consideration will scarcely be appreciated.

2 There must be available sufficient fresh warm air to keep the cabin at a temperature of at least 60 deg. fahr. even though the temperature of the outside air is 45 deg. below zero, a condition that obtains on many of the air lines in the United States during the winter months.

3 There must be available sufficient fresh cool air to keep the cabin at a temperature not to exceed 80 deg. fahr. even though the temperature of the outside air is 100 deg. fahr., or higher, a condition that also obtains on many of the air lines of the United States during the summer months.

4 These two systems cannot be seasonal in their application. Both must be available at all times, because an airplane may meet conditions at one point where the passengers would appreciate a little heat, and an hour later find that cool air is necessary.

5 The fresh warm or cool air must be supplied to the cabin in such a way as not to create an appreciable or unpleasant draft, and it must be entirely free from any traces of exhaust gases or the odor of hot oil. Nothing is more conducive to air sickness than the presence in the cabin of a trace of exhaust gas or the odor of burning or hot oil. The quantity of air supplied should, according to a British report, be sufficient to give a complete change of air in the cabin eight times an hour. Certainly in a small cabin with a large number of persons this is a minimum.

There are many arguments pro and con for the three- and four-engined arrangements for passenger-carrying aircraft. As far as heating the air supplied for the cabin is concerned, it is advisable if possible to accomplish this by making use of some of the exhaust heat. Other systems have been tried in Europe but they have not been satisfactory, and such arrangements as heating by hot water are entirely too heavy for what they accomplish. When there is an engine in the nose of the fuselage, heating by exhaust heat is relatively simple, but with such an arrangement it is extremely difficult to take in air that is at all times free from traces of exhaust gas or oil smoke. This applies equally well in the attempt to secure fresh cool air, for even if the air is fresh it will have been warmed to some extent in passing the engine.

With the engines arranged in two pairs on either side of the fuselage, the question of fresh air is relatively simple, but how to make use of exhaust heat without employing too much heavy piping is a serious problem. To date but one designer in the United States has attempted to use this arrangement of engines, and but little work has been done on the development of a heating system. One difficulty with two sets of tandem engines, apart from the question of heating, is that of providing long manifolds for the rear engines to serve as mufflers and prevent flare from the exhaust at night. Any breakage in this manifold will almost inevitably cause damage to the rear propeller, and in consequence may do serious damage to the airplane.

Returning to the question of ventilation, it is difficult to determine accurately what will be the natural flow of air in the cabin of an airplane, and ventilators must accordingly be placed almost entirely by guesswork. It has been fairly well determined that conditions in the usual type of airplane cabins are such that the air moves from the rear of the cabin toward the front. A single inlet for heated air should therefore be placed in or near the floor at the rear of the cabin, and if there are several inlets they should be so placed that an even distribution will be made as the air moves forward.

Cold-air inlets should be high up in the rear of the cabin. Both warm- and cold-air inlets should be controllable by the attendant in the plane or, if there is none aboard, by the passengers themselves.

Exhaust of the air from the cabin is not so simple, and up to the present only haphazard methods have been used. Air is led in and then left to its own devices to escape through various joints that have not been made airtight. Exhaust fans are heavy, and their proper placement is more or less guesswork. The European report suggests large venturis, probably placed near the front of the cabin. But venturis are unsightly and, if of a size sufficient to accomplish their purpose, will offer considerable resistance as they must be out in the clear in the airstream.

It is customary to place the toilet room at the rear of the cabin. In the light of the foregoing discussion it will be difficult to prevent disagreeable odors, even though such odors be those of disinfectants, from moving the full length of the cabin. This condition has been noted by a number of air travelers. The toilet room should be made as airtight as possible, and very positive ventilation should be provided for that unit alone. Most of the dry-chemical stools now being manufactured for use in aircraft are provided with a large vent, and the end of this pipe should be provided with a very definite means for exhausting the air through it, even though this must mean a venturi on the outside of the airplane.

NOISE AND VIBRATION

The noise from propeller, engine exhaust, and internal engine gear is sufficient in most aircraft to render it one of the greatest objections to air travel on the part of passengers.

The propeller is probably the worst offender and presents the most difficult problem of noise elimination. The high-speed propeller (one turning 1600 or more r.p.m.) makes entirely too much noise, and the maximum intensity seems to come in the plane of rotation. This is a very excellent reason for mounting the engine as far from the cabin as possible. Certainly passengers should not be placed in the plane of rotation of a propeller, even if possible propeller breakage did not make it advisable to keep them away from this position. These considerations would seem to eliminate the pusher propeller for use on passenger-carrying craft. The Guggenheim report indicates that this is the trend of European thought.

The Germans and the English are at odds upon the point as to which gives the least noise: a high-speed engine geared down to a slow-speed propeller, or the usual type of direct-drive engine. Apparently there is evidence to support both contentions. Certainly much is to be gained by the use of a direct-drive slow-speed engine, but a limit is quickly reached here as the size and weight of the power plant increases rapidly with a decrease in normal speed.

Long exhaust stacks are necessary for the prevention of flare at night, and the exhaust noises are reduced materially by their use. This is particularly true if the end of the exhaust pipe can be placed above the top wing or below the lower wing. The question of mufflers has not been considered at all seriously in the United States, and apparently has been given but scant attention in Europe. Mufflers for the higher-powered engines are so heavy

and so large as to be prohibitive. When speed is all-important, as it is in airplane travel, the resistance of mufflers of adequate size cannot be permitted. Nor is an additional weight of approximately 25 lb. per engine very favorably considered.

Research on materials for soundproofing has barely been started. The Bureau of Standards has issued several reports on tests of various materials. These must of course be checked by actual tests in airplanes. To date there have been but three or four materials used for soundproofing the cabins of large passenger aircraft. One manufacturer has used sponge rubber; others have tried various wood-fiber materials such as "Dry Zero," blanket or "Balsam wool," etc. An "acoustic felt" has been employed successfully. This latter has the advantage of occupying comparatively little space and is easier to support than the wood-fiber material, but it has the disadvantage of being fairly heavy, having been developed for building construction rather than for use in airplanes. One manufacturer is now trying a fairly thick plywood with a balsa wood core to serve both as a cabin lining and soundproofing material. For all-metal airplanes a layer of wood-fiber material between the outside shell of the airplane and an interior wall of metal has been found to give excellent results. All of the wood-fiber materials quickly absorb moisture, and the airplane may absorb a large amount of deadweight unless the soundproofing material is carefully sealed in.

The soundproofing material has the additional virtue of serving as a heat insulator and absorbing and damping some of the mechanical vibration that proves troublesome. The proper combination for any airplane should be determined experimentally, but unfortunately this is a long and expensive process. In any event, noise and vibration must be eliminated as completely as possible if the passengers are to travel long periods with any degree of comfort. Some persons quickly become air sick if subjected to vibrations of relatively high frequency and accompanying high-pitch noise.

AIR SICKNESS

The prevention of air sickness is a problem that has occupied the attention of European air lines for some time. Medicinal prescriptions have been tried with but indifferent success. Attention has also been given to the stability and wing loading of the airplane in an effort to minimize the movement of the airplane in rough air. An opinion is expressed in Germany that the airplane should have a high wing loading and a high degree of stability to prevent unpleasant motion in rough air. A high wing loading is not good for airplanes which must operate at extreme elevations, and the British claim that excessive stability does not help. Some of the Dutch lines recommend only a slight degree of stability, so apparently the matter is still open to argument.

Agreement is unanimous on the points that a careful pilot can do much to reduce the effects of bumpy air and that much of air sickness is the direct result of nervousness. Everything possible must be done to prevent the passenger from thinking too much about it.

COMFORTS FOR THE PASSENGER

If the chairs are comfortable, if the cabin is finished in a way to heighten the impression of solidity, the passenger will then have a greater tendency to be at his ease. Once this frame of mind is established, the passenger's mind must be occupied in some way to prevent him from worrying about his safety. The seasoned air traveler actually finds that travel by air is more monotonous than by any other means, primarily because at the altitude above the ground that the airplanes normally fly, the plane appears to be stationary. The fact that there is no movement of objects past the windows makes the journey seem interminable.

The first step in providing something to hold the attention of the passenger is the installation of large instruments in the cabin: an airspeed indicator, an altimeter, and a clock. These must be of a size such that they can be read easily from any seat in the cabin. Glances at these instruments enable the passenger to check up on the journey, and many will make notes of these data for describing their trip to their friends. For the passengers who do not care to read, sleep, play cards, or write (stationery and air-mail stamps should be provided), information should be provided in regard to the interesting details of terrain over which they are passing. Whether this information shall be given by the time-honored "barker" method of an employee with a megaphone, or by a movable map panel mounted at the front of the cabin, or by means of nicely printed souvenirs of the route, is immaterial.

Something must be done to entertain the passengers en route. This is the reason for the use of club and observation cars on the railroads. Automobile road maps are now being printed showing the route, and giving detailed descriptions of all interesting points. Similar information could be supplied each air passenger and would help to prevent the trip from seeming unpleasant or monotonous. One might even predict the use of motion pictures for the purpose of entertaining air travelers.

COMFORT FOR PILOTS

Up to the present time but little thought has been given to providing comforts for the pilots. Unless the pilot is comfortably seated and unless all controls are accessible with a minimum of effort and discomfort to him, he is not going to do the best job of piloting the craft that is possible, and the maximum of safety in operation is accordingly not provided.

All windows in a closed cabin should be designed so that they can be opened very quickly, because they sometimes become misty as a result of a sudden change in temperature. All instruments should be placed so that they may be quickly recognized and easily read. The cabin should be provided with a readily controlled heater.

A point which has only recently been given consideration in automobiles and which has been practically neglected in aircraft design is the location of glass windows in such positions as to reduce reflections from outside lights to a minimum. This is very serious in taking off or landing at night on an airdrome surrounded by street lamps, boundary markers, and other lights incidental to an illuminated town. Only recently a serious accident on a take-off was laid to this cause.

Comfort for the pilot cannot be too heavily stressed. A pilot who is constantly being irritated by the inaccessibility of necessary controls or by an uncomfortable seating arrangement will not be as good a risk for safety as one entirely at ease in his position.

In conclusion, one feels safe in predicting that travel by air will increase surely and steadily. Our passenger craft of today will appear as crude vehicles when they are compared with those of twenty years hence. There is much to be done, and only careful thought and experiment, together with an interchange of ideas such as can be accomplished at meetings of technical men interested in the problem, will enable us to bring this marvelous new means of transportation up to the standards set by other means of conveyance of our modern civilization.

A PROCESS by which hydrocarbon oils and organic liquids are produced from coal through the medium of water gas, has been announced by Fischer in Germany. It is stated that from 1000 cu. ft. of water gas, 1 gal. of organic liquids and 100 cu. ft. of gaseous hydrocarbons can be produced. The organic liquids consist principally of hydrocarbons and alcohols. The gaseous hydrocarbons contain a large proportion of methane.—*The Engineer*, June 14, 1929, p. 655.

Research in the Engineering Colleges

European Types of Education for the Technical Professions—Development of Engineering Education in the United States—Growth of Research Activities in American Engineering Colleges—Backwardness of Research Due to Shortage of Competent Workers

By W. E. WICKENDEN,[1] NEW YORK, N. Y.

THERE are significant differences of national policy concerning the character of the higher schools of engineering and their function in the social order which can be understood only in the light of their historical backgrounds. Fifty years ago Dr. C. O. Thompson, the first president of Rose Polytechnic Institute, observed from his studies of the engineering schools of Europe that there had been little change in their essential character after the first ten years of their existence. It appears that the character of institutions, like that of persons, is largely conditioned by heredity and early nurture. Later growth is more often a maturing than a formative process. Those who know the American colleges of engineering well are aware of the grip of historical tradition which is always more of a ruling force in institutions directed by legislative action, such as colleges, than in industry and other institutions where executive authority prevails.

European Types of Education for the Technical Professions

It may be profitable to spend a moment in a brief review of our national types. Education for the technical professions had its origins in France. The early schools developed within the technical services of the state. Their aims and spirit were exclusively professional. Later the École Polytechnique was created to assure a high intellectual formation in advance of professional training proper. These early institutions had no organic connection with the university system. Their exclusive aim was to provide a *corps d'élite* of engineers for the state and industry. They were strictly teaching institutions, staffed by practitioners and savants whose major interests were elsewhere. The character of the professional teaching was notably high, and many of the teachers were men of great creative genius, but their creative activities were largely done off the premises. The influence of the so-called *grandes écoles* of Paris was world-wide, and not least in America. In France itself they fixed a form of technical education which is still dominant. Their professional discipline is notably thorough, but the professors give only a part-time service, graduate students are unknown, and research is largely a stranger to their precincts. A new type of organization has been growing up in the past 30 years in a group of *institutes techniques* in the provincial universities. While they have been deeply influenced by the strict professional traditions of the *grandes écoles* of Paris, their attachment to the faculties of science had worked in another direction. They have a fair proportion of full-time professors and an active research spirit. Graduate students in French technical schools are rare, almost to non-existence. Provisions for the award of the doctorate in engineering for researches in the universities have only recently come into effect. In general, the place of research in French engineering schools is incidental, secondary, and indirect. France has almost the entire distance to travel in making it a primary force.

[1] Director of Investigation, Society for the Promotion of Engineering Education. President-Elect, Case School of Applied Science, Cleveland, Ohio.

Presented before Section M (Engineering) at the Annual Meeting of the American Association for the Advancement of Science, New York, December 29, 1928.

The historical genius of British technical education must be sought in a welfare movement for workingmen. Industry, scientific inquiry, higher learning, and professional training grew up in separate compartments of British life, and the barriers have not yet been completely leveled. The pioneers of British engineering and industry were workingmen, and it was assumed that a succession would arise by sheer force of native ability, helped on by incidental scientific instruction in evening schools. This idea dominated by far the greater part of British technical education until nearly the end of the last century. The idea of creating a highly trained professional personnel to apply science to industry was largely alien to British thinking in that period. Meanwhile the engineering schools in the university system struggled along against odds of hostility and neglect. The last forty years have greatly changed this situation. Industrial competition, chiefly with Germany and America, and the recent war awakened Great Britain to the greater effectiveness of professional scientific effort. University schools of engineering have been greatly strengthened. The fact that there are two quite distinct types of technical schools has led to a fairly definite division of function. The so-called technical institutions, heirs to the early welfare movement for workmen and controlled by local educational authorities, serve the local population and industries in a most direct manner through their part-time and evening instruction, and provide fully nine-tenths of the technical recruitment. The university schools of engineering, on the other hand, devote themselves to general and fundamental rather than to local and immediate needs. They are small units, with an average of less than 300 students. There are few full professors, and they are selected for their scholarly distinction rather than their activity as practitioners. The possibilities of specialization are very limited and the schools worked at fundamental things both from choice and from necessity. Research has taken a firm rootage in this soil and found it fertile. The crop is choice rather than large. Much of the research in progress is less specialized, and in that sense less advanced, than that which abounds in Germany. There is little direct cooperation with industries but a large share in the work initiated by national agencies, and it aims to be fundamental in the highest degree. The universities are not first-aid stations for British industry, nor are they convenient service stations for routine tests. There is little or no confusion about the aims and nature of research.

Germany is the land of technical research, par excellence. The resurgence of the German states after the Napoleonic era was the historical miracle of the 19th century. There has probably been no other historical movement in which technical education and research have had so large an influence. Poorly endowed with natural resources, and lacking capital for the upbuilding of industry, the German states turned to the creation of scientific knowledge and skill as the means of their economic salvation. In all the history of German technical education there appears the hand of statecraft, deliberately reshaping old agricultural regions into the modern industrial empire. The technical sciences began to gain a precarious place in the German universities late in the 18th century. Once the issue was clearly defined, the new disciplines were thrown out as alien to the genius

of abstract and disinterested learning. Statesmen came to their aid, Count von Gerstner in Bohemia, Nebenius in Baden, Buith in Prussia. It was necessary to begin with trade schools, then to build up a system of secondary education based on modern studies, and gradually to raise the status of a chosen group of polytechnic schools to the level of complete equality with the universities. This process occupied the whole of the last century. In the last half of the period the attaining of a university status became a major issue, and the form of university organization and work became a strong molding influence on the *technische hochschulen*. The Verein deutscher Ingeniure put the whole weight of its influence behind the movement. To this end it encouraged a complete separation of the higher, middle, and lower technical schools, aided in the upbuilding of the *realschulen*, raised funds to finance higher researches, drew the support of the industries to the *hochschulen*, and supported their demands for the right to award the doctorate. At the close of the century the equality of the *technische hochschulen* and the universities was formally recognized by imperial authority. The effect had been to make the *hochschulen* teaching institutions in a comparatively secondary sense, and to make their function the advancement of technical science and art. German industry was quick to follow the lead of the state and the profession in supporting the technical universities as the chief centers of creative effort. A brilliant example was set by the Krupp interests, who established the Kaiser Wilhelm Institute of metallurgical research at the *hochschule* at Aachen, at a cost of over $400,000. Many examples could be cited of the policy of German industries of placing the ablest researchers in professorships and of giving them resources for creative work, rather than drawing them away to more sequestered work under industrial auspices. Furthermore the policy has been quite consistently pursued of concentrating resources and support for research on selected men and institutions, rather than scattering them indiscriminately. In addition to the institute of metallurgy at Aachen, prominent examples are to be found in Professor Rehbock's laboratory of hydraulic construction at Karlsruhe, Professor Becker's automotive institute at Charlottenburg, Professor Nägel's center for research on piston engines at Dresden, the unique laboratory of X-ray technique at Stuttgart, Professor Knoblauch's Institute of heat physics at Munich, the laboratory for high-tension research at Darmstadt, the laboratories of machine-tool technology at Hanover and Charlottenburg, and the institutes of physico-technics presided over by Professor Mode at Charlottenburg and Professor Sachsenberg at Dresden. Statistics are not obtainable, but the ratio of doctor candidates to undergraduates in Germany appears to be quite as high as the ratio of all graduate students to undergraduates in American engineering schools, and as few American graduate students carry their studies beyond the level of the *diplom-ingenieur* in Germany, the contrast is even greater than the ratio indicates. German technical universities are so large and their organization is so highly ramified that opportunity is created for a high degree of specialization. No doubt solutions are found for many more specific problems in consequence of this specialization, but it is not yet possible to say whether the ultimate contributions to progress are relatively greater than under the unspecialized conditions of Great Britain. The present degree of activity in Germany bears out the slogan of one of the German technical societies—"*Die Technik ist Deutschlands wirtschaftheber Schicksal*"—"Technical science is Germany's economic destiny."

Development of Engineering Education in the United States

Engineering education in the United States is an outgrowth of a popular movement early in the last century to promote "the application of science to the common purposes of life." There was no thought at the outset of creating any formal discipline for the profession of engineering. The aim was to give farmers and mechanics such a scientific education as would enable them to become skilful in their professions. Rensselaer had scarcely begun its pioneer work as a school of applied science when the advent of the railroad opened a new chapter in the history of American engineering. The engineers of the earlier decades, a scattered group of land surveyors, builders of roads, bridges, and canals, and practical constructors of machinery, had been largely self-taught, but with the railroad came a demand for engineers with a greater mastery of the scientific resources of the art. There was no existing foundation for a scheme of training by pupilage as in England, and the engineering school arose from simple necessity. The effort to apply science to the common purposes of life passed rapidly into the special form of a professional discipline for engineers. As there were no models in the English-speaking world, they were borrowed from France. With them came the conception of an engineering school as almost exclusively a teaching institution, with a strict disciplinary régime of work. The existing scheme of higher education was of a collegiate rather than a university character. Original scientific inquiry was uncommon. The scheme of engineering education was readily assimilated into the newly developing university system without changing its original conception that its function was to teach that art rather than create it. For a long period the engineering schools had to face the charge of impracticability from the engineering profession and the industries. The traditions carried over from pioneer days, constantly reinforced by British influence and example, tended to emphasize the gap between theory and practice, to the mild disparagement of the former. The schools turned their effort toward making their training as practicable as possible. Shops and laboratories were introduced which simulated industrial practices. Professors sought to gain recognition of their competency by engaging in collateral practice. The teachers had practically no fundamental training beyond the four-year undergraduate course. American authorship was largely a process of compiling and editing. To get hard work out of their students, teachers of engineering worked harder than their academic colleagues in the same proportion. There were here and there inquiring minds which attacked original problems out of native curiosity, but with little encouragement from the engineering profession and the industries, and not much more from the educational authorities.

With the development of the field of electrical engineering in the 80's, followed by chemical engineering in the 90's, and with the gradual infiltration into American schools of men trained in Germany, engineering education began to swing away from its effort to be practical to an effort to become scientific. Many of the professors of these new branches had not been trained as engineers, but as physicists and chemists. Their assimilation to engineering enriched and fertilized it with a new scientific spirit. A bond of understanding sprang up between the schools and the new industries which traced a direct descent from scientific research and technique, whereby the employer took all the responsibility for the practical training of the graduate, and left the school free to devote all its energies to his scientific formation. Conditions begun to be favorable to research in engineering colleges about 1900. Previous to that time there had been few men in the engineering colleges who had either the interest or the qualifications to pursue it, and the physical facilities had been planned with little regard to it. Meanwhile the tradition had been seventy years in the building that teaching is the chief, almost sole, business of the college, that only practical experience and professional reading were needed to qualify the teacher beyond his own undergraduate training, and that collateral practice had the first claim on the spare time of the engineering professor. Re-

search activity gained headway slowly against the inertia of this tradition. Acceleration forces from the state, the engineering profession, and the industries, so marked in Germany, were conspicuously lacking. The movement had scarcely gotten under way when American industry waked up to the potency of scientific research as a competitive weapon. Great industrial laboratories arose and the world was scoured for men to man them. Industry had apparently little compunction in drawing the most promising investigators away from the colleges for its own private needs. Considering the limitations under which research in engineering colleges must be conducted, there can be no doubt that the productivity of the individuals concerned was greatly increased through the transfer. The seriousness of the matter arose from cutting off the potential supply at its source.

GROWTH OF RESEARCH ACTIVITIES IN AMERICAN ENGINEERING COLLEGES

Since the turn of the century the growth of research and quasi-research activities in the engineering colleges has been marked, yet in comparison with the growth of research under industrial auspices it seems that the colleges have relatively lost ground. A fairly complete survey of research activities in engineering colleges made in 1924–1925, showed that 58, or about 40 per cent, had organized arrangements for research, at least on paper. Included in this number were 41 institutions which have organized plans through which the services of the engineering staff are made available in consulting capacities to industries, public-service utilities, and others. If we include all institutions where research is fostered on a purely individual basis, the total rises to 110, or about 70 per cent of the whole group. The total expenditures of the organized research departments in 1924–1925 were close to $1,500,000. Of such expenditures, approximately 11 per cent represented direct appropriations for engineering research by the several states, 40 per cent funds allotted by the colleges from their general funds, and 49 per cent funds derived from outside sources, principally from public professional and industrial organizations. About 70 per cent of this expenditure was made by nine institutions. At least 34 institutions reported full-time research staffs, with a total of between 250 and 300 men so engaged. To this number may be added 350 more who rendered part-time research service for definite compensation and about 200 who gave part-time service without special compensation. The numbers engaged on an individual basis cannot be estimated.

These totals seem impressive. Their chief value is that of an index. It must be remembered, however, that in the same year two corporations in the electrical industry both spent more than double the total outlay of the engineering colleges for research activities, and that at least two in other industries spent more than this total. Furthermore it would be very illuminating, if it were possible, to classify the expenditures of the colleges under such heads as actual research for fundamental knowledge, first-aid problems for industry, routine engineering testing, and what may be called quasi-scientific puttering. Confessedly the amount of real 24-carat research would be relatively small, for the reason that few teachers of engineering are capable of doing it or directing it. But then, the American attitude toward language is notoriously easy-going, and we use the word "research" to mean so many things that we have no word left to *mean* "research."

In view of the contrast between the research activities of the colleges and those of big business, it is safe to assume that corporations at this end of the scale are not going to turn to the engineering colleges to get their fundamental problems solved. For one simple reason, they cannot wait long enough. Furthermore big business has discovered the publicity values of research. Big business can probably be induced to invest money in organized research in engineering colleges only on the plea that such activity is necessary in order to maintain the needful setting and staff for training the grade of researchers and engineers that big business requires. Industry is likely to reply that many of their most productive researchers are drawn from departments of pure science. In any case fundamental scientific research rather than engineering investigation seems likely to get the financial assistance from the source, and it will probably be disbursed through some intermediary or clearing house instead of passing directly to individual colleges and professors. The campaign of the National Academy of Sciences for a national research endowment is working on this principle.

SMALLER UNITS OF INDUSTRY MOST LIKELY TO SUPPORT ENGINEERING RESEARCH IN COLLEGES

At the opposite end of the scale from big business are the innumerable small units of industry which live from balance sheet to balance sheet, with no consciousness of research needs and little margin for the support of such activities. When a small industry meets some acute problem outside the scope of its normal routine and staff, a college professor or laboratory may be a good place to turn for first aid, but this is scarcely research. Yet it is probably to industries in small units that colleges must look for resources to build up their research work.

Many of these smaller units of industry are concerned with the traditional arts rather than the applications of modern science. They are likely to remain deaf to any appeal to support research for the sake of repaying their debt to science or for the sake of maintaining a wide margin between pure knowledge and practical invention. It is just these industries, however, which are most apt to be handicapped by the decline of sporadic invention and likely to profit relatively most from an adequate program of research. Support for such investigation is not to be expected from the single units of such industries, but their state and national trade associations are the natural agencies to foster such activities. There are attractive possibilities of dividends in the form of better methods, economies, and more exact control in the present state of the art. Research looking in advance of the present art is a form of mutual insurance covering the risks of supersession or revolutionary changes in the art.

A recent report of the Babson Statistical Organization announced that an English factory was testing out the production of a flexible, colorless, resilient, non-inflammable glass of organic origin. It went on to say:

> The point of this letter, however, is not only about glass. This is but one of numerous far-reaching discoveries which have recently been reported. We believe that business is entering an era of the most rapid and revolutionary changes in the chemistry and physics of manufacturing. To those who are quickest in taking advantage of such discoveries they present unlimited opportunities, but the manufacturer, merchant, or investor who is asleep to these changes will be hurt.
>
> The time has passed when advertising alone will get sales. The two best salesmen today are a "better product" and a "cheaper way of making it." Research opens the way to both. Furthermore, since the most deadly competition is not between concerns but between industries, we urge clients to combine their energies with others in the same line of business. This saves duplication of efforts, leads to maximum results, and keeps you best informed about all impending developments. Make use of the help which the United States Bureau of Standards at Washington stands ready to give you, and also that of other technical organizations of high standing. Cease worrying about gaining the temporary advantage of exclusive patents, and combine your resources in the way that will do most to permanently help your industry.

[It is significant that the occasion which brought the above report to the author's desk was a request from its authors for a complete list of the engineering colleges with facilities for organized research in cooperation with industry.] The author is strongly of the opinion that trade and industrial associations offer

by far the most promising agencies through which to promote industrial cooperation with the colleges in engineering research. The support of such activities by individual corporations is apt to be sporadic, while trade associations can effectively maintain a continuing relation. The results of work supported by individual corporations are apt not to be widely disseminated or used. A good deal of such support is frankly on a courtesy basis, without a vital interest in its effectiveness or utilization, and with little genuine collaboration between the college and the industry.

A trade association, administering its funds in trust for its constituency and genuinely concerned to show a good return for the investment, provides an excellent medium for the joint shaping of research projects and a widely ramified channel through which to disseminate results. It would seem that the most fruitful result may be expected when a trade association concentrates its cooperative program at a single college, or at a small group of institutions at most. Such work ought not to be located on a courtesy basis or split up on a political basis, but should seek to capitalize distinctive advantages of men, plant, and environment. There is a definite loss when such resources are spread over many institutions as a fairly ineffectual mist, when they might be concentrated into a fairly powerful stream. In this respect the European situation is far better ordered than our own. The policy of concentrating resources abroad has led to the upbuilding of a group of notable and distinctive research centers which are the principal factor in attracting and holding to educational and research work the outstanding authorities in the several fields. The result has been to give the several institutions an individuality quite unknown among us.

The author does not feel that the colleges can rest their case for industrial backing for their research programs on the needs of the colleges, or on an assumed sense of obligation on the part of industry to see that the colleges obtain the men, money, and facilities needed to do their best work. The industries recognize these obligations rather vaguely, and when confronted by the competing pleas of 100 to 150 institutions are justified in feeling rather helpless. The Babson report, however, speaks in the tongue which industry understands and to which it responds.

The work being done at Cincinnati in cooperation with the Tanners' and the Lithographers' national organizations, the power-brake studies at Purdue in cooperation with the American Railway Association, the studies in warm-air heating and ventilating at Illinois, and the great project of the Portland Cement Association in conjunction with Lewis Institute are worthy examples of adequately supported, nationally backed, and effectively concentrated research programs, involving real collaboration between colleges and industries and leading to results of great significance and value.

Backwardness of Research in Engineering Colleges Due to Shortage of Competent Workers

The backwardness of research in our engineering colleges is probably due less to lack of money than to a shortage of competent research workers. Universities and colleges are the only agencies whose special purpose it is to train such men. The great industrial laboratories do much to further the education of their personnel, yet frankly admit their complete dependence on the universities for their training. The engineering colleges are under a heavy burden of quantity production for the every-day needs of industry, and industry is in active competition for the more promising output of the colleges. The inducement to enter active employment at the end of the undergraduate period is very great. It is only rarely that men of creative ability have had the opportunity to test and appraise it at this stage. Between the solicitation of the employing industries and the natural desire to try their powers, we must expect most of the young men who might become productive researchers to pass into industry at this stage. The problem is to rediscover them and get them back after a reasonable period of orientation.

The opportunities in the field of engineering research must be kept more prominently before the student in his undergraduate years. This is the duty of both the engineering schools and the technical industries. Industry needs to recognize its own interest in selling research to a selected few young men, especially among its own employees. Industry needs to send selected men, of clearly indicated ability, back to the graduate schools for further preparation. Both the industries and the organized profession have a duty to make it possible for men of high creative abilities to remain in professorships without undue sacrifice of financial and professional opportunity. American schools of engineering enjoy an unparallel freedom from outside regulation, but suffer from being left to find for themselves in the face of conditions such as these. As a representative of the schools, the author yields to none in the frank criticism of their defects, but he wishes to assert that the engineering profession and the technical industries have received as much as they have deserved at the hands of the colleges, and even more. Without a heightened sense of responsibility on the part of these bodies, and a more effective collaboration between them and the schools, there is little prospect that the defects will be minded.

The Superconductivity of Certain Metals

THE splendid discovery made by Kammerlingh Onnes in his cryogenic laboratory at Leiden, that some few metals became perfect conductors at an excessively low temperature, must admittedly be of the first theoretical importance, and though it is difficult to suppose that any practical use can be made of this extraordinary and astonishing power, it would be rash to feel too assured even of that. It appears that the critical temperature at which this phenomenon suddenly makes its appearance, so that a metal ceases to have any electrical resistance, is for lead 7.3 deg. above absolute zero, for mercury 4.2 deg., and for tin 3 deg. Copper and other good conductors, I understand, do not show this effect, at any rate not yet. How are we to envisage the possibility of a metal offering no resistance to an electric current, so that an induced current, which usually dies out in a small fraction of a second, can last for hours or even days? It is said that a current in lead, for instance, only falls to half value in four days, which, as the late Lord Rayleigh claimed, was a fair approach to infinity. Why is the remaining resistance practically infinitesimal? Low temperature can hardly increase the number of free electrons. I can only suggest that the crystalline form of the metal then arranges itself in chains from one end of the rod to the other, leaving unobstructed interstices along which the electronic "gas" can move freely without encountering opposition, instead of being constantly checked and hampered by encountering the nuclei of atoms in its path.

It must be remembered that perpetual motion of this kind is characteristic of operations in really empty space; ether offers no resistance, and dissipates no energy, as long as things are moving without change of speed. Just as the planets move *in vacuo*, so every atom and every electron is moving in a vacuum. The only obstruction is made by encounters with matter—that is, with other atoms. In free space, an electron can go on forever; and this is what the amperean currents which constitute magnetism are always doing. We do not really generate magnetism, we only open up a closed molecular loop in which an electron is circulating, and cause it to expand so as to surround a perceptible contour.—Sir Oliver Lodge in a lecture before the Institute of Metals. Reprinted from *The Engineer*, May 10, 1929, p. 514.

Recent Developments in Boiler-Metal Embrittlement

Early Investigation of Causes of Embrittlement—All Cracking in Boiler Plates and Tubes Not Caused by Caustic Embrittlement—Cracks Developed in Drums and Tubes Intercrystalline and Found Only in Stressed Metal—Examples of Cracking

By H. F. RECH,[1] DETROIT, MICH.

BOILER-metal embrittlement is a subject in which the engineering profession has been interested for a good many years. It is a subject which many have considered lightly as something which occurs only in isolated sections of the country. There has been a great increase in the number of boiler failures due to embrittlement in the past two years, and these failures have been occurring in practically every section of the United States. Until about a year and a half ago the author considered the so-called "caustic embrittlement" in about the same light as he imagines many others have thought of it—as something the other fellow has which we do not have to worry over.

In December, 1927, however, trouble developed in one of the General Motors plants at Dayton, Ohio, which necessitated the replacement of four 722-hp. boilers which were only one year old. During the investigation of the failure of these boilers trouble was found in three boilers at one of the corporation's plants in Jackson, Mich., in two plants in Pontiac, Mich., one of which had been in operation less than 6 months, in one plant in Memphis, Tenn., and indications of trouble at its plant in Syracuse.

During the preliminary investigation the corporation secured the services of Professors Parr and Straub of the University of Illinois, who are probably the best-known authorities on embrittlement today, of the Pittsburgh Testing Laboratory, the Pittsburgh Steel Company's metallurgist, the chief engineer and vice-president of The Combustion Engineering Corporation, the Babcock & Wilcox Company, the Zeolite water-softener interests, the metallurgist of the Frigidaire Corporation, and its own research laboratory at Detroit. Inasmuch as this trouble covers so much territory, a committee has been formed by the Power and Maintenance Section of the corporation's Works Managers Committee to follow this investigation, and also to look into the practices of the boiler manufacturers, plate mills, and tube mills.

Early Investigation of Causes of Embrittlement

Professor Parr first started his investigation of embrittlement of boiler steel in 1912 because of boiler failures which had been occurring in and around Urbana, Ill. The results of this early investigation were published in Bulletin No. 94 of the University of Illinois in 1917. At that time the trouble was happening in boilers fed from wells supplying water which ran very high in carbonates but with very little or no sulphates present. The bulletin contained a map showing the location of boiler failures which had been traced to this type of water, and made certain statements regarding trouble which had been experienced by the chemical industry due to the failure of steel plates in equipment used for caustic manufacture. The investigation was continued and has been supported financially by the Utilities Research Committee representing the Commonwealth Edison Company, Public Service Company of Northern Illinois, Peoples Gas Light and Coke Company, Middle West Utilities Company, Chicago Rapid Transit Company, and North Shore Electric Railway. The theory at this time was that in a steam boiler, water which contained a high carbonate ratio broke down, forming caustic in the boiler; this collected in all the spaces between the butt straps and the riveted joints, and was then broken down by pressure and temperature and free hydrogen was liberated; this latter was absorbed by the metal at the points which were stressed to or beyond the elastic limit, and the same action took place which is found in steel after pickling and is known as "acid embrittlement," or in nickel plating and is known as "hydrogen embrittlement." A progress report was published under the title "The Cause and Prevention of Embrittlement of Boiler Plate," in Bulletin No. 155, June, 1926.

FIG. 1 SHOWING HOW TUBES CRACK IN THE BEARING SURFACE

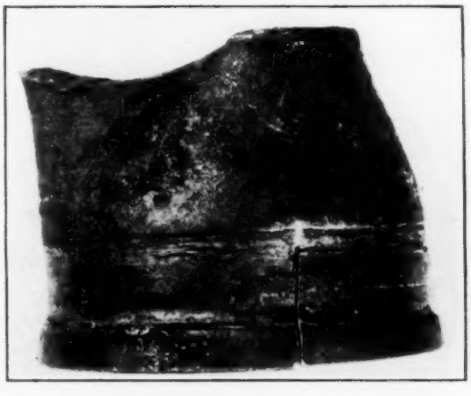


FIG. 2 CLOSE-UP OF CRACKS IN A TYPICAL TUBE

Test boilers were developed in which different steels could be tested at different pressures with different-strength solutions. The steel under test in these boilers was under tension, which could be varied by the use of different springs. These boilers were built very heavy so that tests could be run at high pressures and were electrically heated so that the tests could be run without interruption up to failure of the steel. Certain steels have been found which could not be embrittled, while others have failed in less than four hours. A good many inhibiting agents have been discovered such as sulphates, tannates, and phosphates. Sulphates may be used in many forms such as sodium sulphate, ferrous sulphate, and sulphuric acid. Tannates are very simple to use, but a satisfactory method had not yet been developed to determine the amounts present. Phosphates are very effective

[1] Consulting Engineer, Power and Maintenance Section, Works Managers Committee, General Motors Corporation. Mem. A.S.M.E.

Presented at a meeting of the Syracuse Section of the A.S.M.E., Syracuse, N. Y., March 4, 1929.

and can be used as di-sodium or tri-sodium, or fed as phosphoric acid. Sulphates seem to be the most popular inhibitant on account of the ease of control and the simplicity of the test. Where either sulphuric acid or phosphoric acid is used, it is advisable to have the system under the control of a good water chemist.

The latest report, dated June, 1928, is published as Bulletin No. 177, "Embrittlement of Boiler Plate," and confirms the findings as reported in Bulletin No. 155. A great deal of valuable data has been collected from these test boilers, and the author believes that the latest information eliminates the hydrogen theory. It is now thought that the embrittlement is caused by the breaking up of the binder between the grains of the steel by caustic, which latter is absorbed by the steel along the lines of stress.

A great deal of credit must be given Professors Parr and Straub for what they have done along this line, as they are working from the standpoint of a disinterested party.

The Babcock & Wilcox Company have spent a great deal of time and money on the investigation of boiler-metal embrittlement. This work has been under the direction of J. H. Kerr, who, the author believes, agrees with the University of Illinois investigators in most of their findings.

FIG. 3 SECTION SHOWING STRUCTURE OF TUBE STEEL

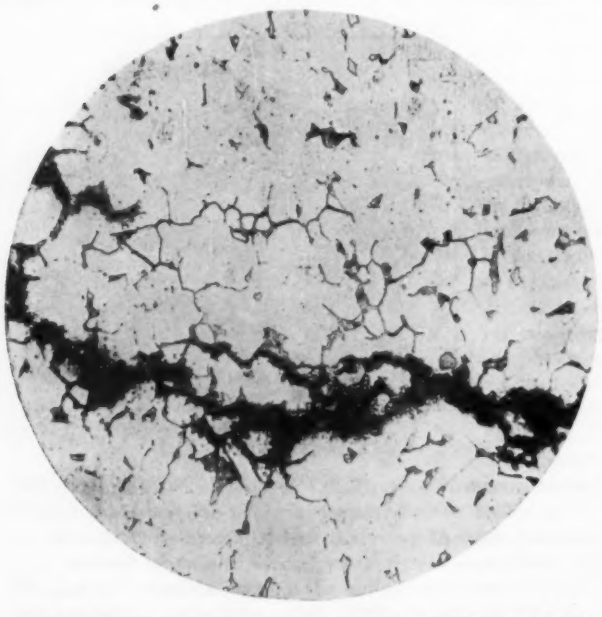


FIG. 4 PHOTOMICROGRAPH OF CRACK MAGNIFIED 125 TIMES

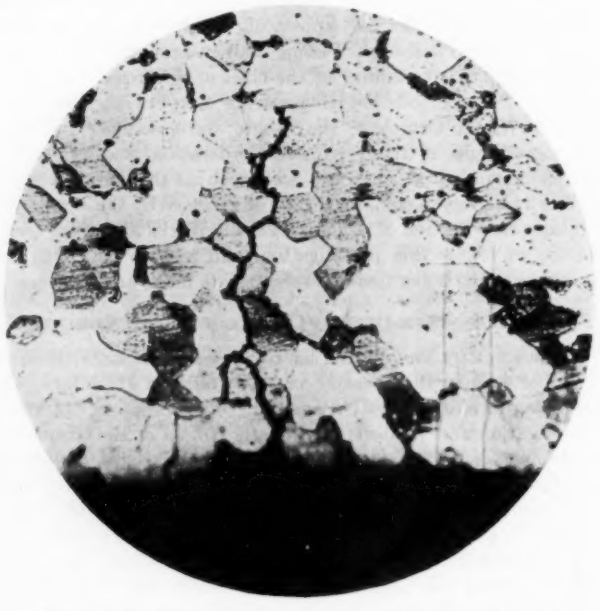


FIG. 5 SHOWING INTERCRYSTALLINE NATURE OF CRACKS

The zeolite interests have been carrying on an investigation, and of course they do not admit the caustic theory. Their method of softening converts the carbonates to sodium carbonates and the sulphates to sodium sulphates. When the sodium carbonates reach a certain concentration they break down to sodium hydroxide, and it is possible to form a dangerous water from a harmless water by this method of softening if the caustic-embrittlement theory is true. The author feels that a great many of the zeolite installations were made without sufficient thought being given to the resultant water conditions, and that this is partly responsible for the great increase in the number of boiler-metal failures in the past few months. Zeolite softeners should not be condemned as being wrong in all cases, however. Where the raw-water conditions are right to start with or where the proper pretreatment or after-treatment is used, this method of softening is satisfactory. The question of cost per thousand gallons of water softened is also a factor and must be given consideration with any type of softener used.

ALL CRACKING IN BOILER PLATES OR TUBES NOT CAUSED BY CAUSTIC EMBRITTLEMENT

All cracking in boiler plates or tubes is not caused by caustic embrittlement, but may be due to corrosion cracks or to fatigue cracks. A careful investigation must be made in each case to determine the cause. There are several factors to be considered such as boiler and setting design, baffle arrangement, workmanship, quality of steel, operating conditions, and water conditions.

In the case of boilers in operation it will not be possible to do very much with design, material, or workmanship, consequently operation and water conditions must be given special attention. In all cases so far brought to light in the corporation's investigation, the ratio of sulphates to carbonates in the boiler water was less than the ratio recommended by the A.S.M.E. Boiler Code

Committee. The boilers which failed in one year at Dayton had a ratio of 0.3 to 1 where the present recommendation would be 1 to 1, and the author understands the Boiler Code Committee are considering raising this ratio to 0.014 times the steam pressure, which in the case cited would require maintaining a ratio of 2.1 to 1. Where the action was slower it was found that the corporation's ratios were nearer the recommendations. It should be understood that the ratios recommended are not the average ratios carried but the minimum allowable. Where the water conditions have met the requirements of the A.S.M.E. code, no trouble has been encountered.

For example at Jackson, Mich., the corporation absorbed a plant adjoining its present Jaxon Steel Products property. The plant in question had four bent-tube-type boilers, and the plant absorbed had three bent-tube-type boilers of the same make and size. Both of these plants were operating on the same water supply, the same load conditions, the same steam pressure, and with about the same percentage of make-up water. The boilers in the old plant after ten years' operation with water carrying the recommended sulphate ratio are in perfect condition, while those in the new plant using water treated by a process which prevented scale formation but did not maintain the proper sulphate ratio were damaged in four years' operation. This shows that the water is a factor and must be given special attention.

In high-pressure plants, for example, boilers operating at 600 lb. pressure, under the new ruling it would be necessary to main-

FIG. 6 BOILER WITH 410 3½-IN. TUBES LESS THAN ONE YEAR OLD, 145 OF WHICH CRACKED

tain at least a 8.5:1 ratio. This might cause the formation of a sulphate scale and might make the use of phosphates necessary.

CRACKS DEVELOPED IN DRUMS AND TUBES INTERCRYSTALLINE AND ONLY FOUND IN STRESSED METAL

The cracks which have developed in the drums and tubes in the boilers have been intercrystalline and have only appeared where the metal was under stress in the vicinity of the yield point of the metal. With the corporation's present method of building boilers, it is impossible to build a drum with longitudinal seam without stressing the metal around the rivet holes.

Stresses are set up when the hot rivets are put in the holes. These stresses are greatly increased during the formation of the head. Stresses are set up in the main plates and butt straps near the edges when the plates are sheared or when they are cut by the acetylene torch. It is also impossible to roll a tube into a boiler without exceeding the elastic limit of the metal of the tube. It is true that during the operation of a boiler there are stresses set up in the riveted joints due to the difference in temperature between the inside of the plate which is in contact with the water and the outside of the plate which is in contact with the hot gases. We know, however, that where the water conditions are right these stresses are not sufficient to crack the plates. We also know that where embrittlement has occurred and the boilers have been replaced with others of the same design having drums built with the same stresses in the riveted joints and the water condition has been corrected, there has been no further trouble with embrittlement.

Calking is an item which should be given special attention. Inside calking prevents the leakage of boiler water between the

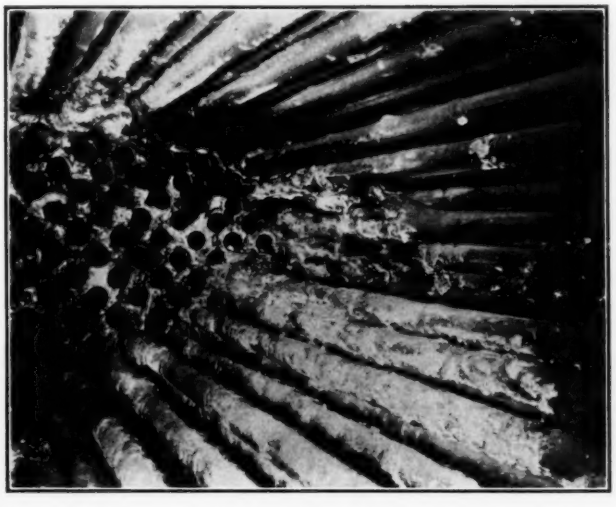


FIG. 7 SHOWING HOW IMPURITIES IN THE HIGHLY CONCENTRATED BOILER WATER BAKED AROUND THE TUBES

butt straps and main drum sheets, and does not allow the caustic to concentrate.

EXAMPLES OF CRACKING

Fig. 1 shows how tubes cracked in the bearing surface. It should be noted that the cracks do not extend beyond the bearing surface in any case. The flattened section shows the ductility of the metal. No cracks appear at the flattened section.

Fig. 2 shows a close-up of cracks in a typical tube. It will be noted that the cracks do not connect but overlap in a good many instances. Chemical analysis of the tube steel shows carbon 0.15, (Spec. 0.08–0.18), manganese 0.41 (Spec. 0.30 to 0.60), phosphorus 0.025 (Spec. 0.04), max. sulphur 0.035 (Spec. 0.045 max.). This steel is accepted as a good tube steel; the structure (Fig. 3) is likewise satisfactory and perfectly normal, and indicates that the tube had been properly annealed. Thus the tube meets all the requirements that can be checked from a chemical or metallurgical standpoint.

Fig. 4 is a photomicrograph of the crack magnified 125 times, showing small cracks radiating from both sides of the main crack and following the grain boundaries in all cases.

Fig. 5 shows very clearly the nature of these cracks, which in all cases examined were intercrystalline. This tube trouble seems to be the first real bad case so far brought to light. In one 722-hp. boiler which contained 410 18-ft. 3½-in. No. 10 gage tubes, 145 cracked tubes were found (Fig. 6). These tubes were less than one year old and were scattered pretty evenly through the whole boiler. Fig. 7 shows how the impurities in the highly concentrated boiler water baked around the tubes, completely plugging the boiler.

The scale shown in Fig. 8 analyzed as 46.2 per cent sodium sulphate, 4.2 per cent sodium chloride, 7.3 per cent calcium carbonate, 3.9 per cent ferrous carbonate, 8.5 per cent silica, and 27.9 per cent sodium carbonate. It would not dissolve and had to be chiseled from around the tubes. The cracks radiating from the rivet hole in the angle iron show the effect of the caustic on structural steel. This angle iron was on the inside of the drum and supported the steam purifiers. After finding this condition in the tubes, leakage was discovered along the longitudinal seams of the main drums, and on examination it was found the rivet heads could be knocked off very easily. Fig. 9 shows some of these rivets and heads.

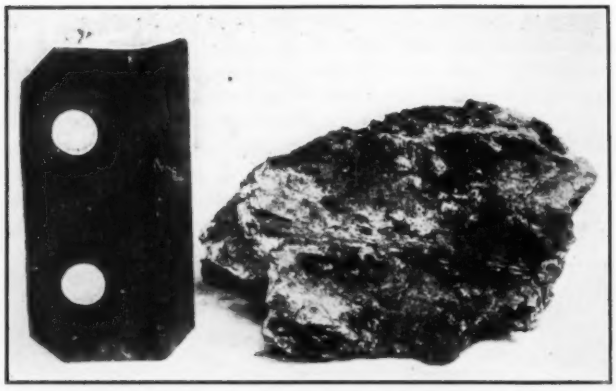
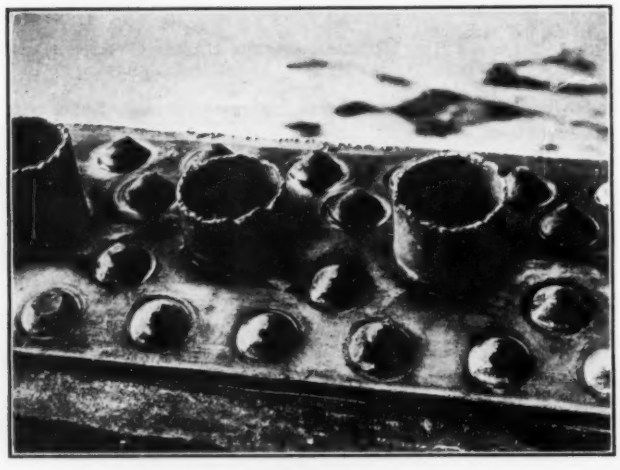


FIG. 8 SHOWING HARD TYPE OF SCALE WHICH HAD TO BE CHISELED OFF

FIG. 9 RIVETS WITH HEADS CRACKED OFF



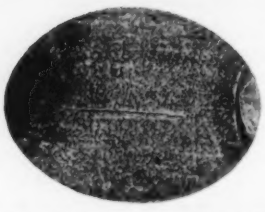


FIG. 10 SHOWING CRACKS IN OUTSIDE BUTT STRAPS FROM RIVET HOLE TO RIVET HOLE

Cracks were found in the outside butt straps from rivet hole to rivet hole (Fig. 10) practically the full length of the drum. Fig. 11 shows this butt strap after removal. These cracks do not connect but overlap just as do the tube cracks, and under the microscope they exhibit the same intercrystalline structure as that shown by Fig. 5. Fig. 12 also shows the type of crack found following the strain lines set up in steel during the riveting operation.

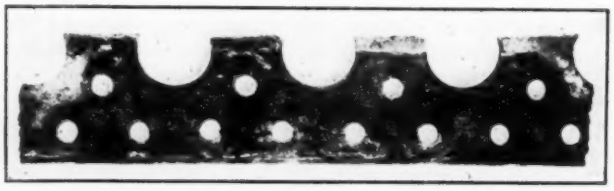


FIG. 11 SHOWING BUTT STRAP AFTER REMOVAL

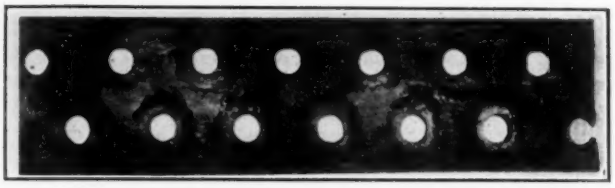


FIG. 12 TYPE OF CRACK FOUND IN BUTT STRAP

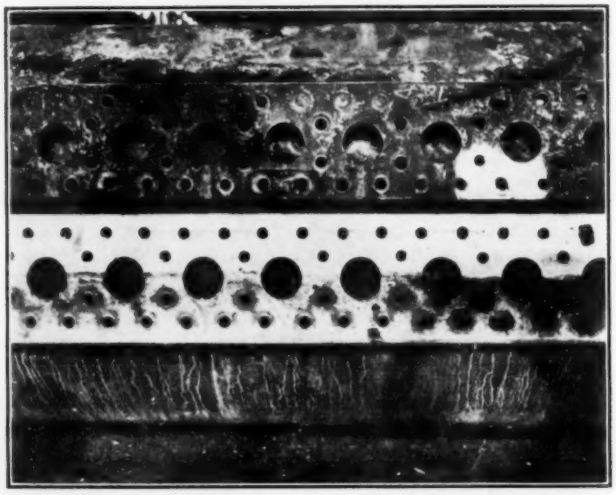


FIG. 13 CRACKS FOUND ON INSIDE OF BUTT STRAP

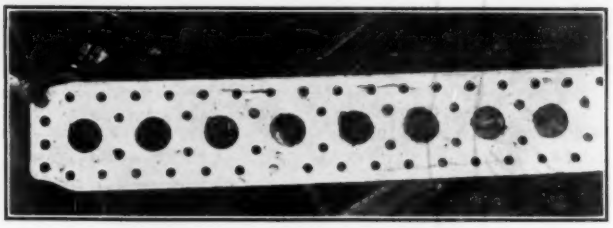


FIG. 14 CRACKS FOUND IN A DOUBLING STRAP NOT SUBJECTED TO STRESS

Fig. 13 shows cracks found on the inside of a butt strap which showed leakage along the longitudinal calked seam, but in which no cracks were visible on the outside and on which the rivet heads could not be knocked off. Due to the leakage the strap was removed for examination, and it was found that in most cases where the outside butt straps showed leakage after the removal of the rivets, the main drum sheet and inside strap would also show cracks. These cracks were always below the water line and were all on boilers which had been calked on the outside only.

Fig. 14 shows cracks in a doubling strap used to reinforce the drum where the circulating tubes are rolled in, but which does not carry any strain as there is no joint in the plate at this point. It will be seen that it is cracked along both outside rows of rivets.

All of the photographs reproduced in Figs. 1–14 were from the Dayton boilers, and the conditions shown are typical of those found in other types of boilers belonging to the corporation. These conditions do not seem to be confined to any one type of make of boiler, as they have been encountered in three types or boilers built by three different manufacturers. All of the failures, however, have been in boilers that were calked on the outside only.

Although tests show that there are steel plates available which cannot be embrittled by caustic soda, they are nevertheless not practical for boiler purposes on account of price and lack of present means of handling them in boiler shops.

Chemical tests show penetration of the caustic soda beyond the line of failure, indicating that the action is not due to hydrogen gas as was first believed but to a breaking down of the binder between the grains in the steel.

The author is open minded on this matter, however, and due to lack of any better information is maintaining the sulphate-carbonate ratios as recommended by the A.S.M.E., which seems to be the best inhibitor known at the present time. In the meantime the investigation is being carried on, and he is always glad to receive suggestions or information concerning this problem.

Journal-Bearing Design

Two papers presented at a session on lubrication at the 1928 A.S.M.E. Annual Meeting, New York, December 3 to 7, dealt respectively (1) with the friction of journal bearings as influenced by clearance and length, and (2) with journal running positions.

The object of the first paper was to provide, through investigation, a reasonably accurate experimental indication of the behavior of small-bore full-journal bearings of various clearances and lengths under normal working conditions. The second paper gives results of an investigation undertaken to find whether under any circumstances a journal will rise higher than the bearing center in any clearance bearing. Abstracts of these papers immediately follow.

Friction of Journal Bearings as Influenced by Clearance and Length

BY S. A. McKEE[1] AND T. R. McKEE,[2] WASHINGTON, D. C.

THE factors that determine the performance characteristics of journal bearings might conveniently be divided into two classes, operating factors and factors of construction. Among those classed as operating factors (i.e., those that are dependent upon the particular conditions of operation) are the load on the bearing, the speed of the journal, the temperature of operation, and the viscosity, oiliness, and amount of the lubricant. Among the factors of construction (i.e., those that are built into the bearing itself) are (1) the absolute size as represented by the journal diameter; (2) L/D, the ratio of the length of the bearing to the diameter of the journal; (3) C/D, the ratio of the diametral clearance to the diameter of the journal; (4) the condition of the bearing surfaces, which is dependent upon the materials of which the journal and bearing are made, their smoothness, and their deviation from true cylindrical form; and (5) the means for applying or retaining the lubricant, such as oil holes, oil grooves, and relieved spaces.

The object of this study is to determine the effects of changes in two of the most important factors of construction in a normal bearing—namely, the L/D and C/D ratios—in the hope that the results may be of value in the formulation of rational methods for bearing design.

[1] Assistant Mechanical Engineer, Bureau of Standards.

[2] Research Associate, Bureau of Standards (A.S.M.E. Special Research Committee on Lubrication).

The method chosen for showing the effect of changes in clearance and length was to measure the frictional resistance of a set of bearings having a given length and clearance under a wide range of operating conditions, and to repeat the measurements with others sets of bearings having different lengths and clearances, the same journal being used in all the tests.

A convenient graphical method for evaluating the results obtained is to compare the respective coefficient-of-friction curves of bearings having different lengths and clearances, plotting the coefficient of friction f against the generalized operating variable $\mu n/p$ which denotes the product of the viscosity of the lubricant by the number of revolutions per unit time divided by the bearing pressure (load per unit projected area). The justification and advantages of the generalized variable in place of the separate operating factors have been previously discussed. The particular choice of units and notation employed consists in expressing the viscosity in centipoises, the speed in revolutions per minute, and the bearing pressure in pounds per square inch, and in denoting the respective quantities by Z, N, and P when so expressed. The graphical method of this paper may therefore be very simply described as a comparison of the f-(ZN/P) curves for bearings of the same absolute size having widely different values of L/D and C/D.

The friction machine used in this work was originally designed to use four connecting rods of an automobile engine, with the babbitt-lined "big end" bearings serving as test bearings, mounted on a steel shaft set in a lathe. These rods were used in the tests where the L/D ratio was 1.00, but in all the others solid-bronze babbitt-lined bearings, clamped in special holders of the same general shape as the connecting rods, were used. These four rods are fastened to a frame by means of eyebolts and clevises in such a manner that they lie in a horizontal plane with the two end bearings on the opposite side of the shaft from the two in the middle. The frame is suspended by two equalizers mounted on a cross-beam fastened to the frame just above the shaft. Load is applied to the bearings by compressing the calibrated coil springs mounted on the sliding eyebolts fitted to the end rods.

Oil is fed to the center of the unloaded sides of the bearings by lines of rubber tubing from a glass bottle. The oil is forced from the bottle by the house air pressure of about 7 cm. of mercury.

The working temperature of the bearings is measured by

copper-constantan thermocouples fastened to the loaded sides of the second and fourth bearings. When using the regular automotive connecting rods where the bearing shell was thin, the thermocouples were soldered in the center of the outside of the bearing cap. When using the special bearings, however, connectors were made, which, when screwed in the longitudinal center of the loaded side of the bearing shell, brought the thermojunction to within about $^1/_{16}$ in. of the babbitt lining.

Temperature control is provided by circulating water through the hollow test shaft by means of a small motor-driven gear pump connected to a 20-gal. supply tank.

In order to conserve both materials and labor and yet cover the full range of C/D and L/D ratios desired, the same test shaft was used for all the tests, and but one set of bearings for all the tests with a given L/D ratio. The procedure was to run the tests for a given L/D ratio with successively increasing clearances, starting with the smallest clearance desired and reaming the bearings out to the next larger size after each test was completed.

Tests were made upon bearings having the following L/D and C/D ratios:

L/D = 2.80, with C/D = 0.00075, 0.00100, 0.00200, and 0.00455
L/D = 1.00, with C/D = 0.00046, 0.00065, 0.00100, 0.00200, 0.00400, and 0.01000
L/D = 0.75, with C/D = 0.00043, 0.00093, 0.00200, and 0.00400
L/D = 0.50, with C/D = 0.00048, 0.00100, and 0.00400
L/D = 0.25, with C/D = 0.00038, 0.00091, 0.00191, and 0.00400.

The bearing surfaces were finished with a special type of commercial reamer which provided a smooth, accurate bearing surface. The proper diameter for each bearing was based upon the average diameter of that part of the shaft at which it was located, and the diameter of no single bearing was allowed to deviate more than ±0.0002 in. from that required to give the average C/D ratio of the whole set of four. The measurements of diameter were made with a special type of commercial internal micrometer and were accurate to within ±0.0001 in.

The test shaft used in these tests was made of a high-carbon tungsten tool steel, its heat treatment being: heated at 1500 deg. fahr., held for 30 min., quenched in oil, reheated at 850 deg. fahr. for 45 min., and air cooled. It had a Brinell hardness of about 179. After treatment it was ground and lapped. The average diameter at the journals was dependent upon the location and length of the bearings, the maximum value being 1.25054 in. and the minimum 1.25043 in., these values being correct within ±0.00005 in.

The lubricant used in all the tests was a mineral spindle oil having a viscosity of 126 sec. Saybolt Universal at 100 deg. fahr. The average running temperature was about 77 deg. fahr., the absolute viscosity of the oil at this temperature being about 42 centipoises.

All of the bearings were tested without being run in. The runs were made in the decreasing order of ZN/P. The first point of a run was obtained by using a light load combined with a high speed, and the succeeding points were obtained either by decreasing the speed or increasing the load.

The total load per bearing ranged from 25 to 200 lb., and the speed range was from 15 to 700 r.p.m.

The results at the higher values of ZN/P are so consistent that it appears worth while to represent them by a simple equation whereby the frictional torque of a given bearing may be estimated for most normal operating conditions.

The results indicate that for bearings having an L/D ratio of 1 or thereabouts, the Sommerfeld[3] or Harrison[4] equations will give results accurate enough for practical purposes where the value of ZN/P is greater than 100 and where the coefficient of friction is greater than 0.01. Thus the charts based upon Harrison's equation for bearings of various nominal C/D ratios in Howarth's graphical analysis[5] are suitable for bearings of this type. These equations, however, do not take end effects into account, and thus can be considered fair approximations only where L/D is greater than about 0.75.

In developing corrections for various L/D ratios Petroff's[6]

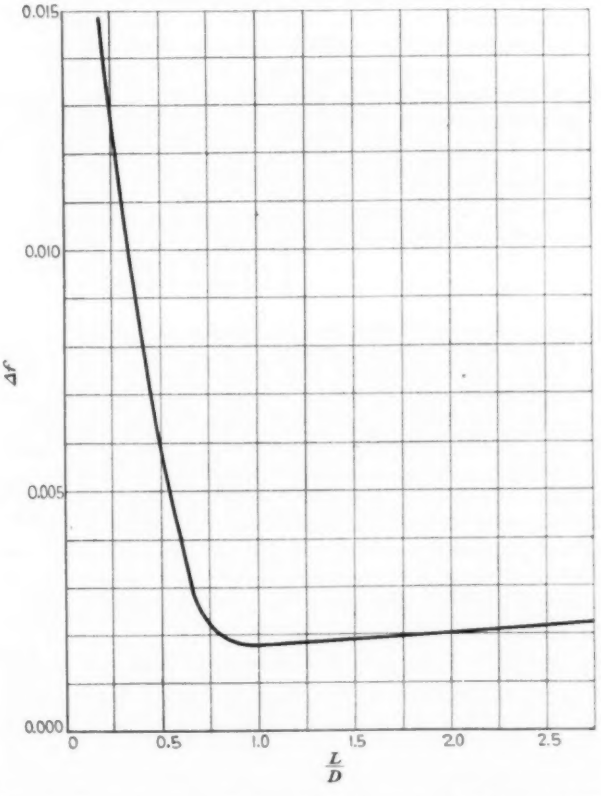


FIG. 1 CORRECTION TO PETROFF'S EQUATION FOR VARIOUS L/D RATIOS

equation, owing to its simplicity, appears to be most suitable to use as a basis. While this equation is based upon the assumption that the journal is at all times concentric with the bearing, the deviations between it and the more rigorous Sommerfeld or Harrison equations are negligible at values of ZN/P above 100 and values of f above 0.01.

The curve in Fig. 1 shows the average value of Δf, the correction to Petroff's equation, for the various L/D ratios. The maximum error in using this method is about 16 per cent, the average being about 4 per cent. Thus the equation

[3] See paper by A. Sommerfeld, *Zeit. für Math. u. Phys.*, vol. 50 (1904), pp. 97–155.

[4] W. J. Harrison, "Hydrodynamical Theory of Lubrication," Trans., Cambridge Philosophical Society, vol. XXII (1913), pp. 39–54.

[5] H. A. S. Howarth, "A Graphical Study of Journal Lubrication," Trans. A.S.M.E., vol. 45 (1923), pp. 421–448; Part II, vol. 46 (1924), pp. 809–832; Part III, vol. 47 (1925), pp. 109–114; reprinted by The American Society of Mechanical Engineers, 29 West 39th St., New York, N. Y.

[6] "Neue Theorie der Reibung," St. Petersb. Acad., 1883; German trans., Hamburg, L. Voss, 1887; French Trans., *Rev. de Mécanique*, vol. 7 (1900), pp. 571–602.

$$f = 473\left(\frac{ZN}{P}\right)\left(\frac{D}{C}\right)10^{-10} + \Delta f$$

the first part of which represents Petroff's formula in our present units, should be reasonably accurate for the practical determination of friction losses in small-bore full-journal bearings provided ZN/P is greater than 100 and f greater than 0.01. It is of course understood that the speed and load are fairly constant, that an adequate supply of oil is maintained at a relatively low pressure, and that there are no oil grooves in such a location on the bearing surface as to materially affect the pressure distribution in the film.

The limit of the scope of this investigation is to provide a reasonably accurate experimental indication of the behavior of small-bore full-journal bearings of various clearances and lengths under normal working conditions.

While the results of the tests at the higher values of ZN/P are fairly consistent with theoretical equations based upon the viscous shear of the lubricant, it would not be justifiable to predict that these results would be a reliable indication of the characteristics of large bearings operating at high speeds and high loads, since it is reasonable to expect that under the latter conditions the effects of such factors as journal deflection, distortion caused by uneven heating, and changes in viscosity due to temperature gradients in the oil film may be of considerable magnitude.

The inconsistencies shown by the results at the lower values of ZN/P are an indication that considerable caution should be used if the carrying capacity of a particular bearing is determined by any method based upon the theoretical value of the minimum thickness of the oil film.

Further steps toward a better understanding of the performance of full-journal bearings suggested by these tests are (1) to make similar tests of the effect of changes of clearance and length, using larger diameter bearings under heavier loads and at higher speeds, and (2) to determine the carrying capacity of bearings by a study of the effect of changes in bearing metal, lubricant, and overall dimensions upon the point of minimum friction of bearings finished by the usual commercial methods.

Journal Running Positions

BY H. A. S. HOWARTH,[7] PHILADELPHIA, PA.

THE classic theory of bearing lubrication propounded by Reynolds and extended by Sommerfeld has shown that when a journal runs in a full bearing with a complete film, the journal center will run opposite the center of the bearing when the journal load acts directly downward against the bearing. The classic theory has, the author believes, also shown that the journal will never rise higher than opposite the bearing center if the bearing measures 180 deg. long and if the load line bisects that angle.

Consequently the impression has gained ground that under no circumstances will the journal rise higher than the bearing center in any clearance bearing—if the classic theory is correct. The present investigation was therefore undertaken to find out whether that current impression was reasonable. A study of journal running positions was undertaken for clearance bearings whose resultant pressures do not bisect the bearing angle.

The 120-deg. bearing was chosen for the present study because it approximates the bearings widely used in steam turbines. Other angular lengths will be studied later if the results of the present study indicate that an extension of the work is desirable.

The result of our analysis proves that the current impression is erroneous. The journal may run with its center higher than that of the bearing, if the load, speed, viscosity, clearance ratio, and α/β ratio are compatible therewith. This must be so if the classical theory is correct.

The present analysis indicates that the load direction upon a partial bearing has an amazing influence upon the running position of the journal. It also indicates that no matter how high above the bearing center the journal may run at any finite speed, it will return to run concentric with the bearing at infinite speed.

This study disclosed other interesting phenomena that are explained in the complete paper. Side leakage was neglected. The viscosity was assumed constant. Influence of friction upon the direction of the resultant pressure was estimated. Consequently the present work is readily comparable with that of Reynolds, Sommerfeld, Harrison, and with previous work of the author.[8]

Having applied the new charts developed in the paper to the solution of several hypothetical problems, one will realize that it is a serious handicap to have charts only for the 120-deg. bearing. We shall therefore endeavor to have this analytical work extended to include bearings with different angular lengths. The amount of labor required for this extension will be much less per bearing than for the first one covered by the paper, because much of the preliminary work has now been done.

The paper here abstracted indicates that the journal lift, under adverse conditions, may be much greater than generally expected. This may result in rubbing against the cap. The design of the bearing cap therefore becomes important. The methods of providing and removing the lubricant are dependent upon the cap design. The cap may be fixed in an offset position so as to maintain a pressure film that will reduce the journal lift. Such a cap would be suitable for one direction of rotation. If made so as to adjust itself automatically it would be suitable for either direction of rotation.

The journal lift will not be serious if the oil is not heavy for the *load-speed-clearance* combination employed. In other words, a bearing that is too lightly loaded for the *oil-speed-clearance* combination may give trouble by rubbing against the cap. Again, if the speed is too high for the *oil-load-clearance* combination, similar rubbing may take place.

High-speed bearings will require further study to take into account the initial pressure at the leading end of the bearing. In general it may be expected that high-speed bearings will have journal lifts that correspond with longer bearings of greater α/β value, α representing the angle from leading edge of partial bearing to position of resultant pressure, and β the circumferential (angular) length of the bearing. Hence when a journal runs in a 120-deg. central bearing at high speed its lift will follow more nearly one of the paths for $\alpha/\beta > 0.5$. The greater the speed the higher the value of the equivalent α/β. These predictions are suggestive of what is to be expected from studies taking account of the initial pressure.

The side-leakage effect in journal bearings[9] is still open for rigorous analytical investigation, as is also the influence of viscosity decrease as oil passes through the bearing film.

Much experimental work is under way from which useful factors for designing engineers may result. Important in this class is the work being done by the U. S. Bureau of Standards under the direction of M. D. Hersey.

[7] Vice-President, General Manager, and Chief Engineer, Kingsbury Machine Works. Mem. A.S.M.E.

[8] "A Graphical Study of Journal Lubrication," Part I, Trans., A.S.M.E., vol. 45, p. 921; Part II, vol. 46, p. 809; Part III, vol. 47, p. 1073.

[9] A. G. M. Michell's study of side leakage for inclined flat surfaces with rectilinear motion is the only sound analysis at present available. It indicates what may be expected for curved surfaces in short-arc partial bearings. See "The Lubrication of Plane Surfaces," by A. G. M. Michell, Melbourne, *Zeitschrift für Mathematik und Physik*.

Tungsten Carbide as a Cutting-Tool Material

The design and fabrication of tools from tungsten carbide, the availability of the material, the long life of such tools and the increased production which their use affords, results obtained in machining malleable and gray cast iron, bronze, bakelite, and alloy steels, as well as the effect of their introduction on machine-tool design, are dealt with in a paper and a report of an A.S.M.E. research committee presented at the Rochester, N. Y., meeting of the Society, May 13 to 15 last. These will appear in complete form in the forthcoming Machine Shop Practice Section of A.S.M.E. Transactions. Abridgments are given below.

Tungsten Carbide Cutting Tools

By HENRY J. LONG[1] and W. PAUL EDDY, JR.,[2] SYRACUSE, N. Y.

IT IS the purpose of this paper to present the results of some experiences in the fabrication of tungsten carbide tools and of both successful and unsuccessful attempts to apply them to various types of work, so as to assist in the readjustment of manufacturing practices which must necessarily take place in order to allocate to tungsten carbide its true place in industry.

Design and Fabrication of Tools

The brittleness of tungsten carbide alloys is a property which encourages the use of a large, and especially a thick tip in relation to the size of the cut to be taken. The factors limiting the tip size may be the cost of the material, the necessity for ample support of the cutting tip by a stronger and tougher material, and the space available for the operation of the whole tool. It is also necessary, in designing a tool, to consider chip space, especially in the case of a multiple-edged tool, in order that there may be no likelihood of chips becoming packed on the tool face to the extent that chipping of the edge results.

The comparative weakness of this material demands as sharp a cutting angle as possible, in order to reduce the chip pressure. In order to use a large rake angle, however, without crumbling at the edge, absolute rigidity is essential. As more rugged machines are built and as fluctuations of power applications are lessened, it will become possible to use steeper cutting angles. The angles are not the same, of course, for all jobs, but depend upon the character of material being cut, type of tool used, speed, feed, and condition of the machine. As an example, we are using on lathe tools for malleable cast iron a front rake of 5 deg. and a side rake of 5 deg.; we have hopes of increasing these angles for steel as we approach freedom from vibration in operation.

Inasmuch as heat generated in the tool is relatively unimportant, we find it possible to use broader-nosed tools of tungsten carbide than of high-speed steel, thus distributing the cut over wider areas and lengthening the life of the tools.

Partly in the interests of economy, the company with which the authors are associated is studying methods and technique of making tools tipped with tungsten carbide alloy. With money tied up in such expensive material, it is imperative that the investor be in position to use it as efficiently as possible and to eliminate losses resulting from delays in procuring, regrinding, repairing, or remodeling tools.

Inasmuch as it is usually impossible to purchase a piece of tungsten-carbide alloy of nearly the size required in a tool, the first problem encountered is that of removing from a small bar or stick of the alloy a piece of the desired size and shape, with minimum effort and the least possible loss. In the first place, the bar of alloy should be purchased with its application in mind, so that two dimensions of the proposed tip will have been fulfilled. Then it would appear merely necessary to cut the length desired by means of a thin grinding wheel of the special composition recommended for grinding tungsten carbide alloy.

It is not so simple, however. We have never been able to cut completely through even a thin piece of this alloy with a grinding wheel; the piece always fractures before the job is finished. We have found, after many trials, that to grind on one side only (one of the broader sides if the section is not square) directly into the piece until it cracks is as sure as any method of resulting in a flat fracture in the desired plane. The notching should be done on a small surface grinder. We are using a 7-in. wheel, not less than $^3/_8$ in. thick, on the circumference of which has been dressed a rim approximately $^1/_{16}$ in. thick and $^1/_4$ in. wide, with fillets at the shoulders and with a rounded edge.

The next step is mounting the tips on the holders. Firm support is of paramount importance. The tip must fit its seat closely and should have contact over not less than three sides. Blades of multiple-edged tools, such as reamers and facers, may be made of thin, flat pieces of the alloy, which should be mounted in slots sawed at angles of 10 to 12 deg. to the direction of motion at the cutting points. This method results in locking the blades against the pressure of the chip which would otherwise pull out the blades during operation.

The brazing may be done by heating the holder and tip in a furnace having an atmosphere of nitrogen or hydrogen, using copper as the brazing material. Good results can also be obtained, however, without such a furnace, by heating in the flame of a blow torch, provided a brass alloy be substituted for copper. The strength of a well-brazed joint of brass may not be as great as that of an equally good copper joint; but owing to the fact that the brass flows more freely, a complete filling of the joint can be made much more easily under the blow torch with brass than with copper.

The tip or blade may be ground to its final shape after mounting. We find that a fixed position on a surface grinder results in a rounding or crumbling of the point; consequently we grind by hand, moving the tool across the side of the wheel. Good results in roughing are obtained with a certain Czechoslovakian silicon-carbide wheel and with 60-I to 80-I Crystolon wheels. For finishing, a 100-I Crystolon wheel is satisfactory. Wheel speeds are approximately 3400 r.p.m. We now rarely find it necessary to resort to lapping as the finishing operation.

Cutting Malleable Cast Iron

As is well known, the properties of tungsten carbide alloy point to the low-tensile materials as the field of greatest service. We have found a number of operations on malleable-iron castings to which these tools are applicable.

One of these is the breaking down or chamfering of the flanges of differential-case castings. One typical case requires a chamfer of about $^1/_4$ in. on a flange of 9-in. diameter. Best previous results were obtained with Stellite, cutting at a speed of 72 r.p.m.,

[1] Experimental Dept., Brown-Lipe-Chapin Division, General Motors Corp.

[2] Assistant Metallurgist, Brown-Lipe-Chapin Division, General Motors Corp.

Contributed by the Machine Shop Practice Division and presented at the Rochester Meeting, Rochester, N. Y., May 13 to 15, 1929, of The American Society of Mechanical Engineers. Abridged.

Note: Statements and opinions advanced in papers are to be understood as individual expressions of their authors, and not those of the Society.

and with a feed of 0.014 in., the production per grind averaged 200 pieces. By simply replacing the tool with tungsten carbide alloy, the average production jumped to over 7000 pieces per grind.

On the same lathe set-up, the flange is rough-faced. Stellite was formerly used, making a cut $^1/_{16}$ in. deep, with a feed of 0.014 in., at the same speed as above, 170 ft. per min.; the tool life was about 150 pieces per grind. Tungsten carbide tools are averaging 700 piece each grind.

Finish-facing of the same flange is then performed on another lathe. High-speed steel tools formerly used produced an average of 400 pieces per grind. Tungsten carbide tools operating at a speed of 300 ft. per min., with 0.013 in. feed, average 12,000 pieces a grind. These tools do not give quite as smooth a finish on the work as did high-speed, but their big advantage, aside from increased production, is the elimination of size variation. With the tungsten carbide no adjustment is required throughout a day's run, and no difference in size between the first and last piece can be detected.

Another malleable-cast-iron application is that of line-reaming pinion bores of differential carriers. A double reamer $3^3/_8$ in. in diameter, each section having six blades, is run on one such job at 80 r.p.m., removing about 0.015 in., with a feed of 0.052 in. High-speed steel reamers produced an average of about 1500 pieces per grind, and each reamer had a total life of about 6000 pieces. The tungsten carbide reamers average 9500 pieces per grind, and the life of a reamer is approximately 28,500 pieces. In this application better finish as well as less size variation is obtained with tungsten carbide. The rate of production, furthermore, has been increased approximately 20 per cent, as the high-speed reamers were run at half the above speed with a little greater feed.

Use on Gray Cast Iron

Certain pinion spacers are now made of malleable cast iron. In order to obtain greater crushing strength and to effect savings in material costs, it is desired to replace malleable with gray iron for these parts. The advent of tungsten carbide tools is making the desired move possible. Experimental work on this job has not as yet been completed, but it is indicated that these operations will soon be carried out on gray-iron spacers on a drill press, using two double counterboring tools, each of which will face one end and bore the adjacent diameter. The rate of production is expected to be double that of the present method.

Cutting Alloy Steel

We have been cautious in applying tungsten carbide to the machining of steel. Nevertheless, there is at present one important job on which a saving is being made by its use. Bevel-drive gear forgings, usually of $3^1/_2$ per cent nickel steel, were formerly made with minimum machining allowances of $^1/_{16}$ in. on backs and $^1/_{16}$ in. on faces. The initial operation was to take a fairly heavy facing cut from the backs of the forgings on heavy machines with high-speed steel tools. Owing to the powerful chucking required, an occasional forging was distorted so that when it was removed from the machine after the cut the back would not be quite flat. This condition caused trouble in subsequent operations.

The present method is to specify 0.070 in. allowance for machining on the face and to merely clean up the forge-shop excess of $^1/_{32}$ to $^1/_{16}$ in. from the back with a tungsten-carbide facing tool on a lathe. This means that a comparatively thin cut is taken on a surface so abrasive and at a speed so high that a high-speed steel tool will not finish one piece. The remaining operations on the gear blank of turning, boring, and facing are handled in two set-ups on large vertical automatics.

The speed of the initial facing cut on a typical forging, which is $8^1/_2$ to 10 in. in diameter, is 120 r.p.m., or 267 to 314 ft. per min.; the feed is 0.020 in. A tungsten-carbide tool will face 150 to 175 pieces per grind and will have a total life of 3000 to 4000 pieces. Ignoring the former cost of high-speed tools, we find that a tungsten-carbide tool costing $24 and facing 3600 pieces does the work for $^2/_3$ cent per piece. Against this we place an actual saving of 2 to 3 cents in materials on each forging, an increase in production of finished gear blanks of at least 50 per cent (on a man-hour basis) and the elimination of warping troubles. Some difficulty was experienced in obtaining a lathe which would stand up under the high speeds required to make this facing operation economical, and before such a lathe was used the tungsten carbide tools gave much trouble in chipping as a result of lack of rigidity.

Unsuccessful Applications

It is natural that, in seeking for applications on which tungsten carbide tools will improve the product or lower costs, some failures will occur.

We have been unable to make a cutting-off tool for automatic screw machines which operates successfully; every tool chips very quickly.

We have not been able to make a tungsten carbide tool work satisfactorily on Mult-Au-Matics; the large overhang permits sufficient vibration to chip the tool.

This alloy has also proved ineffective in rough-turning the outside diameter of the flange of a certain differential case of malleable cast iron, owing to the irregularity of depth of cut.

We are still having some difficulty in either purchasing or manufacturing multiple-edged facing tools from which the tungsten-carbide blades will not pull out during operation.

Conclusions

It is evident, from our experience, that tungsten carbide alloys are to have an important place in the fabrication of ferrous metals. The occupying of this place will come, however, only after careful investigation of all likely applications, and progress in this direction will necessarily be gradual and slow, especially in view of the very high price which must at present be paid for the alloy. Although it is further evident that the next move in the continuous battle between machines and tools is now up to the machine builders, we nevertheless firmly believe that the future of these alloys as factors in efficient manufacturing is in the hands not of the makers of the tool materials nor the builders of the machines but of the users of machine tools.

The Present Status of Tungsten Carbide as a Cutting Material[3]

By FRANK C. SPENCER, KEARNY, N. J.[4]

AT THE present time there are two tungsten carbide products available in the United States; namely, (1) Carboloy, manufactured and sold by the Carboloy Company, of New York; and (2) Widia, manufactured by the Krupp Company of Essen, Germany, and imported by Thomas Prosser & Son, New York. The Wesson Sales Company, which has offices in Detroit and

[3] Report of Sub-Committee on Machinability of the A.S.M.E. Special Research Committee on Cutting of Metals.

[4] Assistant Superintendent, Machinery Procurement, Western Electric Co., Kearny Works.

Contributed by the Machine Shop Practice Division and presented at the Rochester Meeting, Rochester, N. Y., May 13 to 16, 1929, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS. Abridged.

NOTE: Statements and opinions advanced in papers are to be understood as individual expressions of their authors, and not those of the Society.

Chicago, are sales agents for the Widia alloy in Western territory.

In addition to carboloy, two other brands will be manufactured in this country, viz., Strauss metal, by the Ludlum Steel Company, and Dimondite, by the Firth-Sterling Company.

The demand for tungsten carbide in this country has grown with great rapidity owing to the inordinate amount of publicity which it has received. Widia metal has been on the market since last fall (1928), both in the form of rough tool bits and finished tools. There has been little difficulty in securing the former, but the production of the finished tools is limited owing to the fact that the operations of brazing the tips and of grinding and lapping the tools constitute a very specialized process, and one which requires experienced workmen to secure the best results. The Wesson Sales Company has recently installed a large amount of equipment for producing finished tools and making reasonably quick deliveries.

The Carboloy Company have only recently placed their product on the market. They do not furnish rough tips as they seem to prefer to retain control over the processes of welding the tips and of finishing the tools to the proper cutting angles. They have been making tools for some time, but apparently their entire output has been absorbed by the General Electric Company, either for experimental work or for actual production purposes.

The price of these brands seems to run uniformly at $1 per gram ($454 per lb.).

Some Experiences of Industry With Tungsten Carbide

A survey of the results obtained by several concerns in the Chicago and Detroit districts indicates that the life of the tungsten carbide tools, where they can be used, is many times greater than that of high-speed-steel tools, even in the speed range where high-speed steel attains its maximum efficiency.

A large valve company has tooled an automatic chucking machine with tungsten carbide tools, replacing high-speed-steel tools, for machining a bronze valve disk. The average life of the high-speed-steel tools was 600–800 pieces per grind, while that of the carbide roughing tools was in the neighborhood of 27,000 the speeds, feed, etc., being identical in each case. The tungsten carbide finishing tools had produced about 28,000 parts at the time of our visit and were apparently as good as new.

Another manufacturer replaced high-speed-steel tools with tungsten carbide tools for machining a malleable-iron part having brass inserts. This operation likewise was performed on an automatic machine with no changes except the substitution of tools. The best tool life obtainable with high-speed steel was from 3 to 8 hours' operation per grind. The first set of tungsten carbide tools ran for over six weeks before requiring regrinding.

A large automobile company has obtained data on drilling bakelite with a $^9/_{16}$-in. drill. The results indicate that on a strictly comparative basis tungsten-carbide-tipped drills produced 10,700 holes per grind, and the high-speed drills only 155.

A large clutch manufacturing company found that by using tungsten-carbide-tipped drills and counterbores for drilling and counterboring bakelite-asbestos clutch plates they could secure in the neighborhood of 50,000 holes per grind as compared with a production of about 1000 holes with high-speed-steel drills.

Effect on Machine Tools

It will be apparent that much of the tungsten carbide now in use has been placed in operation, first, in order to overcome machining difficulties and thus to decrease the "down time" which is ordinarily consumed by the frequent grinding of tools, and second, to obtain greater production by increasing cutting speeds where it has been possible to do so without danger of damaging the machines. Wherever the speeds were increased it was of course necessary to install larger motors to give the additional power required. However, on account of the limitations imposed by the machines available, it has in no case been possible to utilize the maximum benefits which could otherwise have been secured from the use of tungsten carbide tools.

It is questionable whether tungsten carbide will ever be capable of withstanding heavier cuts than are now customarily taken with high-speed-steel tools and it would seem, therefore, that whatever machine-tool developments will be required on account of the introduction of this new material will be largely incidental to the increases in cutting speeds which it is generally agreed are possible.

This Committee feels that a great deal of development work must be done before machines can be designed with full confidence that they will be suited to the additional demands which will be thrown upon them. Assuming that the speeds are increased to the maximum which the tools can stand while maintaining the usual chip cross-sections, it will be apparent that a number of practical considerations must be taken into account, such as:

1 Bearing designs must be altered and additional rigidity provided throughout on account of the structural weakness of tungsten carbide. The cutting edges of tungsten carbide tools will break if appreciable chatter is permitted.

2 Chip disposal must be taken care of on a far larger scale.

3 Indications are that the problem of providing suitable coolant which has been so important heretofore may be eliminated.

4 In automatic machines the mechanism controlling the action of the tools must function in the minimum of time in order that the greatest advantage may be derived from the new material.

5 It is quite reasonable to suppose that fewer changes in speeds will be required, and that there will be corresponding simplifications in spindle drives.

6 Lathe-tailstock dead centers will not last with the cutting speeds which will be used, and centers equipped with anti-friction bearings will be necessary.

Summary

Some of the considerations which will have an important bearing on the question of how machine tool developments will be affected by the introduction of tungsten carbide tools have been mentioned. It remains to be seen to what extent the machine tool industry as a whole will be involved in this development.

It seems fairly certain that the whole bulk of the machine tools which fall into the class termed "production machine," will eventually require design modifications in order to comply fully with the newer requirements. At the present time, however, the status of the development of tungsten carbide tools would not warrant radical changes in the design of milling machines and drill presses, since neither milling cutters nor drills have so far been very successfully made up with tungsten carbide cutting edges for use in machining high-carbon steel or alloy steel. As far as lathes and similar machines are concerned, it is safe to predict far-reaching developments on the basis of what has already been accomplished.

It is quite certain that further development of tungsten carbide tools will proceed much faster than that of machine tools, and it would seem highly desirable, therefore, that the machine tool builders undertake immediately a comprehensive study of all the factors involved in the adoption of the new tool material with a view to effecting the transition as economically as possible.

This Sub-Committee recommends that the A.S.M.E. Special Research Committee on Cutting of Metals urge the formation of a new committee, by the Society's Main Research Committee, which shall have for its purpose the correlation of the activities of the various organizations which may be engaged in research connected with the development of machine tools to meet the newly arisen needs.

A Typical Incipient Forest Fire

Steam-Generating Apparatus in Forest Areas as Related to Causes of Forest Fires[1]

Causes and Extent of Damage of Forest Fires—Fire-Prevention Equipment for Locomotives and Logging Engines—More Strenuous Efforts Needed if Forests Are to Be Preserved

By A. C. COONRADT,[2] NEW YORK, N. Y.

IN A PAPER entitled "Spark Arresters and Forest Fires" presented before the Wood Industries Division of the A.S.M.E. at its 1925 Annual Meeting, J. S. Mathewson called attention to the great annual loss in this country due to forest fires. He also made some definite recommendations as to the part the Society should play in the study of steam-generating apparatus used in forest areas, in an effort to reduce this loss. Specifically he recommended that tests be made on the various types of existing fire-protective equipment used on locomotives, donkey engines, sawmills, etc. operating in forest areas with a view to developing improved types. As a result of the interest shown in Mr. Mathewson's proposal the Society's Main Research Committee decided to investigate carefully the need for such a research.

Preliminary investigation revealed that the problem had already had considerable attention. As early as 1907 Dr. W. F. M. Goss of Purdue University made extensive tests of locomotive drafting apparatus for the American Railway Master Mechanics Association at Purdue University, the results of which appeared in a book entitled "Locomotive Performance." Later, in 1923, L. W. Wallace at the same university made further studies along the same lines and reported them in a book entitled "Fire Losses, Locomotive Sparks." The California Forestry Committee, an association of timber owners, lumbermen, railroads, forestry officials, and other interested groups in California, has also carried on an extensive investigation of the problem. The results of this work were discussed before the Pacific Logging Congress

[1] A summary of surveys conducted for the A.S.M.E. Main Research Committee through certain of its Local Sections and Student Branches.

[2] Assistant Professor of Mechanical Engineering, New York University. Assoc-Mem. A.S.M.E.

in October, 1926. In addition several other lumbering and railroad groups have given and are still giving the problem considerable attention.

As the result of its preliminary studies the Main Research Committee decided to proceed along the lines of determining through surveys to what extent fires were caused by the mechanical equipment operated in, or adjacent to, forest areas, and whether the fires caused by such equipment resulted from faulty design or from improper use and maintenance of the apparatus. This work was authorized in September, 1926, and for the past two years surveys have been carried on under the supervision of Local Sections and Student Branches of the Society in the three great logging regions of the country, namely, the Northwest, the Middle North, and the South.

The program laid out for the surveys included (1) determination of the importance of the problem as indicated by the percentage of forest fires in the district attributed to steam-generating apparatus; (2) a study of federal and state laws to reveal how completely the subject was covered by laws and the extent to which these laws are enforced; and (3) determination of the types and effectiveness of the fire-protective equipment used through actual visits made to lumbering and railroad operations. This program was carried out in Oregon by Everett Kuhn, graduate in mechanical engineering at Oregon State Agricultural College, under the direction, first, of the author of the present article, and completed under Prof. S. H. Graf of the same college. Carl A. Herrick, secretary of the A.S.M.E. Minneapolis Local Section, directed a similar survey in the state of Minnesota. Under the direction of Prof. W. R. Wollrich of the University of Tennessee, Ewell B. Pittard, a student of the same university, carried out the survey in the Southern Appalachian region. The surveys were conducted during the fire seasons of 1927 and 1928, and complete reports have been presented to the A.S.M.E. Main Research Committee by the three groups. It is the purpose of this article to summarize these regional reports, which probably will be published in full at a later date.

TABLE 1 SUMMARY OF DAMAGE AND AREA OF FIRES BY GROUPS

Group	Number of fires	Damage to timber, young growth, and forage	Damage to improvements and forest products	Total damage	Ratio of groups to entire U. S.	Area burned		Ratio of groups to entire U. S.
						Acres		
Entire U. S.	51,021	$15,447,769	$5,497,147	$20,944,916	100	15,827,331	100	
Northeastern	713	784,974	102,553	887,527	4.3	158,927	1.3	
Appalachian	3,876	1,164,897	176,364	1,341,261	6.4	526,256	3.3	
Southeastern	19,154	7,125,700	1,089,077	8,214,777	39.2	8,484,654	53.6	
East Mississippi	2,277	606,821	122,733	729,554	3.5	434,020	2.8	
West Mississippi	8,906	2,545,160	369,124	2,914,284	13.9	4,046,229	25.6	
Lake states	2,352	1,164,706	2,809,000	3,973,706	19.0	827,391	5.2	
Prairie	100	1,539	2,552	4,091	...	100	...	
Rocky Mountain	3,242	877,413	27,816	905,219	4.3	323,845	2.1	
Pacific	5,384	1,176,569	797,928	1,974,497	9.4	966,587	6.1	

TABLE 2 SUMMARY OF CAUSES OF FIRES BY GROUPS

(Per cent of number of fires)

Group	Light-ning	Camp fires and smokers	Brush burning	Incen-diary	Misc. and unknown	Lumber-ing	Railroads
Entire U. S.	7.4	17.7	15.3	18.5	23.0	5.8	12.3
Northeastern	0.5	16.4	11.0	1.7	37.2	0.6	32.6
Appalachian	0.8	17.0	12.0	8.4	31.2	5.8	24.8
Southeastern	2.4	14.0	20.3	26.9	19.6	8.4	8.4
East Mississippi	6.0	19.4	18.4	15.9	20.4	5.7	14.2
West Mississippi	2.1	19.3	15.2	31.1	20.9	5.8	5.6
Lake states	0.8	18.6	18.1	1.9	38.9	2.1	19.6
Prairie	51.9	13.0	6.5	2.6	16.9	2.6	6.5
Rocky Mountain	45.7	20.6	5.8	3.6	11.8	3.1	9.4
Pacific	26.1	27.1	8.1	10.4	17.8	5.7	4.8

CAUSES AND EXTENT OF DAMAGE OF FOREST FIRES

Records of the Forest Service have been briefly summarized in Tables 1 and 2 to show the extent of damage and the causes of fires in the various sections of the United States. In both tables the figures are for the ten-year period ending in 1925, and are averages for this period.

The Southeastern group stands out in this table as suffering a much heavier loss than any of the other sections. The distribution of the damage among the states comprising this group is as follows:

	Per cent of group
North Carolina	16.8
South Carolina	11.8
Georgia	21.5
Florida	15.2
Alabama	24.1
Mississippi	10.6
	100.0

In South Carolina, Georgia, Florida, and Mississippi there was no state-organized protection, and in North Carolina and Alabama part of the area was unprotected. This probably accounts, to some extent at least, for the heavy losses in this section.

Under the item "lumbering" listed in Table 2 are included all fires caused by lumbering operations such as those resulting from blasting, brake shoes, foul blocks, refuse burners, etc. A detailed record for the state of Oregon shows, however, that about 90 per cent of the logging fires are caused by sparks from the steam equipment. On this basis we may estimate that 17.5 per cent of the forest fires are caused by the steam-generating equipment of the lumbermen and railroads, and that the direct annual damage chargeable to this source is of the order of $3,600,000.

The Forest Service supplements their figures for damage as follows:

> These totals do not take account of the vast amount of intangible and indirect damage resulting from forest fires, such as that through decay of damaged timber, replacement of desirable species of trees by less desirable but more fire-resistant ones, soil deterioration and erosion, loss of wild life, uncertain stream flow, interrupted tourist traffic, and the like.

The figures of Table 2 show quite clearly that the question of the control of fire along the right of way of the railroads is the most serious from the purely mechanical standpoint.

THE RAILROAD FOREST PROTECTION CONFERENCE

The Railroad Forest Protection Conference called by the Department of Forests and Waters of the State of Pennsylvania in December, 1927, was attended by representatives of all the railroads operating in the state and by several officials of outside roads who had met with success in fire-prevention work. During the conference the relation of the railroad to the forest-fire situation was fully discussed in its many phases by men who had been in close touch with the actual conditions in the field, with the result that there was a valuable interchange of ideas and experiences.

Of the forest fires in Pennsylvania about 32 per cent are charged against the railroads, and the records for the states of New Hampshire, Massachusetts, Connecticut, and New Jersey show that the situation is about the same in these states.

Railroad fires may be caused in various ways, namely, by

1 Sparks emitted from the stack
2 Sparks from ash pans
3 Hot bricks or clinkers thrown out by firemen
4 Discarded matches and smoking material
5 Fuses carelessly set off

6 Losing control when burning grass from right of way
7 Burning old ties without proper precautions
8 Overheated brake shoes, and by
9 Broken power lines.

With this variety of causes to face it is obvious that the problem of preventing railroad fires is not a simple one.

The measures that must be taken to minimize these fires may be enumerated as follows:

1 Motive-power equipment for fire prevention
2 Rigid inspection of fire-prevention equipment
3 The development of safety strips along right of way
4 Patrol after trains
5 Methods for promptly reporting fires
6 Section forest-fire wardens
7 Education of the employees and the public.

FIRE-PREVENTION EQUIPMENT FOR LOCOMOTIVES

The modern large locomotive is capable of developing between 3000 and 4000 hp., and this power is developed within a very small space. On account of this space limitation very high combustion rates must be used, ranging in maximum values from 120 lb. of coal per square foot of grate per hour in the strictly modern locomotive to values approaching 200 lb. on some of the locomotives of older design. This high combustion rate requires induced draft, which is obtained by discharging the exhaust steam up the stack. Under these conditions a large percentage of the lighter particles in the fuel pass from the firebox at the rear of the locomotive through the tubes and thence, if unrestricted, through the smokebox and up the stack, without being completely consumed and still in an incandescent state.

In locomotives burning coal various arrangements of baffles and screens are used in the smokebox, the idea being to prevent the escape of the incandescent particles until they are of such a small size that they will cool before reaching the ground. The difficulty in such arrangements is in screening sufficiently to prevent fires and at the same time maintaining sufficient draft for the proper operation of the locomotive. The exact arrangement of baffle plates and screen varies on different railroads and according to the kind of coal burned. The most usual arrangement is to have a baffle plate in the smokebox just ahead of the tubes. This baffle deflects the gases and causes the cinders to impinge against the sides of the smokebox, thus breaking them up to some extent. A screen, usually cylindrical in shape, is put in front of the baffle, and the gases must pass through this screen before reaching the stack. The draft-producing exhaust nozzles usually stick up through the plate at the bottom of the cylindrical screen.

An old and extensively used front-end arrangement, known as the Master Mechanics' Front End, is shown in Fig. 1.

The effectiveness of all forms of smokebox screens has been greatly enhanced by the use of an oblong-mesh instead of the square-mesh screen formerly used. Thus a screen with a $^3/_{16}$-in. $\times$ $^3/_8$-in. opening will screen the cinders out better and offer less draft resistance than a screen of $^1/_4$-in.-square mesh.

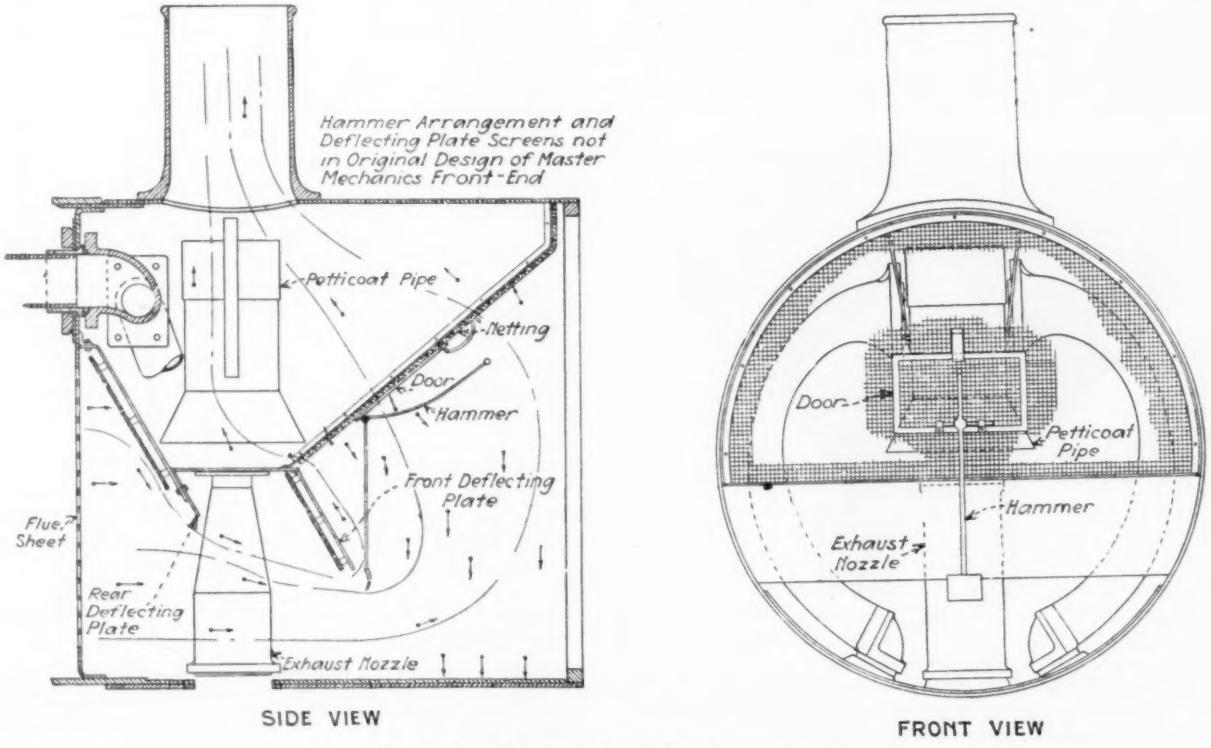


FIG. 1 SELF-CLEANING FRONT-END ARRANGEMENT

Arrangements have been tried in the smokebox whereby the cinders were deflected to the bottom and cleaned out at the end of each trip. These have not met with success, however, as they often cause overheating of the front end, which in turn causes warping of the frame.

The use of the smokebox screen in wood-burning locomotives is not as satisfactory as the spark arrester built into the stack. In firing up, when wood heavy in pitch is used the screen clogs up and is cleaned with difficulty. The hooded stack, though offering greater air resistance and weight, has less trouble from this source and is generally used as being the lesser of the two evils from the operating standpoint. To keep a spark-arresting

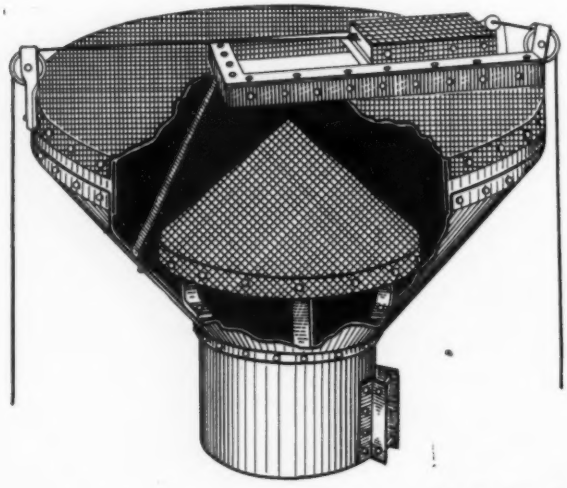
device effective requires careful installation and frequent inspection, repair, and cleaning.

At the end of four years it is generally necessary to rebuild the front end and ashpan of new material. There seems to be a considerable difference of opinion among operators, forestry officials, and manufacturers in regard to the efficiency of the spark-arrester and ashpan designs now in use. The consensus of opinion seems to be that present troubles are due more to faulty maintenance or improper use of the equipment than to inadequacy of the equipment itself.

A forestry inspector of railroad equipment seldom has an easy time in getting the locomotive spark arresters and ashpans brought up to a state of repair that will insure safety. Working with a large organization and being unfamiliar with the routine, it is often difficult for him to find an official who will authorize the expenditures necessary, allocate the work in the shops and roundhouses, and do the necessary follow-up work.

Quick repairs with light materials, cement and putty, have been found to be poor economy in construction or patching, as a lower cost over a period of time will be obtained if substantial construction is used. Welding in recent years has greatly simplified this work. In Minnesota a $^3/_8$-in.-diameter rod is used as a gage in ashpan and front-end inspections, and any openings larger than this were ordered closed.

As between sparks from the ashpan and from the stack there is no definite information to show which constitutes the greater risk. Ashpans have received a great amount of attention from locomotive designers in recent years, with the result that locomotive efficiencies have been improved and fire hazards reduced.



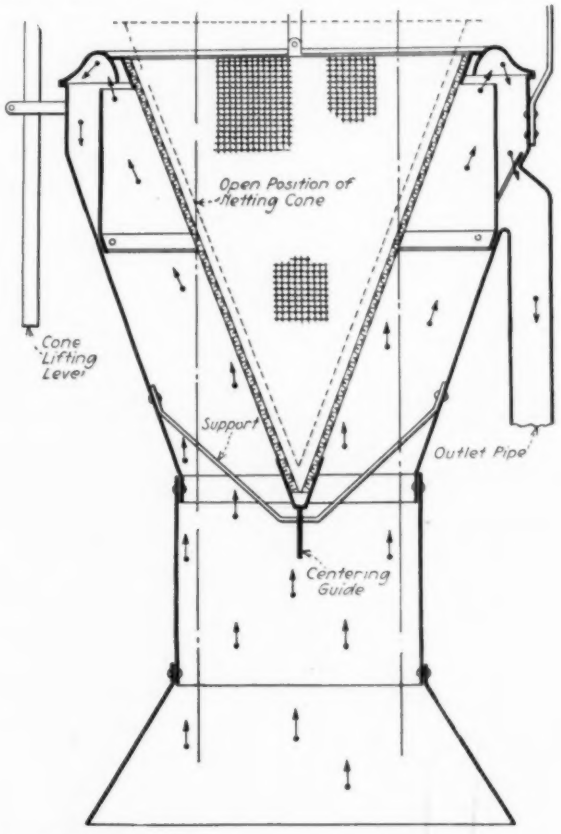


FIG. 2 TWO TYPES OF SPARK ARRESTER

The opinion of the East and South seems to be about unanimous that the use of oil fuel would eliminate practically all fire hazard from the locomotive in districts where oil could be obtained at a price low enough to permit its use. This opinion is not concurred in by forestry officials, operators, or manufacturers in Oregon and Washington, where oil is extensively used. Oil-burning locomotives frequently start fires by ejecting sheets of incandescent carbon which have apparently formed as a scale on some of the cooler parts of the furnace or tubes. An unprotected oil-burning locomotive is looked upon as more of a menace than a wood burner equipped with a proper arrester.

FIRE-PREVENTION EQUIPMENT ON LOGGING ENGINES

As shown in Table 2 the logging operations themselves do not cause as many fires as do the operations of trunk-line railroads. The fires that result from this cause, however, are responsible for damage in excess of $1,000,000 per year, and so deserve attention.

As in the case of the locomotive, so it is with the logging engine. It is necessary to limit the size of the equipment, at the same time developing as much power as possible. This again results in a high combustion rate, requiring induced draft, which is almost invariably obtained by exhausting into the stack.

As most logging outfits use vertical boilers, the smokebox arrangements employed in locomotives are not suitable and some kind of a spark arrester is used in the stack.

The simplest form of such a spark arrester consists of a cylindrical screen of the same diameter as the stack, placed as a cap on the top of the stack. These are practically worthless as they interfere with draft to such an extent that the fireman invariably pokes a hole in the screen to relieve the situation if the impinging cinders do not do the job for him. An improvement on this design is the "Merry Widow" used quite extensively on the smaller machines of the Pacific Coast. The "Merry Widow" is a spherical screen having a diameter about three times that of the stack, and is built upon a structural frame mounted on top of the stack. When well built and maintained this simple arrangement is quite effective, especially if a fine rectangular-mesh screen is used. The screen, however, requires frequent replacement, and is often not replaced as soon as it should be.

Another very simple and effective device consists in putting a return bend in the stack so that its end points downward. A tank of water is placed so that the sparks are discharged into it and are extinguished. This device is used quite generally throughout the United States. The principal objection to it

seems to be that it is quite heavy and hard to support; further, the tank requires frequent cleaning, and water in the tank must be replaced at frequent intervals.

One spark arrester now undergoing development on the Pacific Coast aims to break up the cinders by the use of a series of plates and deflectors causing the exhaust to change its direction.

The cinders in striking the baffle plates are broken up and extinguished before leaving the stack. Preliminary tests of this device seemed to indicate that it would offer too much resistance, but changes in the arrangement of the deflecting vanes may remedy this trouble.

There are several good patented designs of spark arresters using screens. In one device an unscreened opening permits free draft when the engine throttle is closed, thus aiding in getting steam up in the morning and in allowing it to build up more rapidly between hauls. As soon as the throttle is opened the slide closes automatically and the exhaust is completely screened in.

Another patented arrester, which has been used extensively on the Pacific Coast with wood fuel, is so designed that the cinders are deflected by a screen into an annular ring from which downspouts carry them to the ground. If the downspouts are maintained in a spark-tight condition and made to discharge into water or a properly cleared space, this type of arrester is quite satisfactory. Cleaning devices of various kinds are used, usually consisting of steam jets directed against the screen.

Each of these spark arresters has its following in the logging fraternity, and heated discussions among operators of the same equipment as to the relative merits and deficiencies of the different types are of frequent occurrence.

The field men of the Forest Service seem to think that most of these devices are good if properly installed and maintained. The difficulty comes more in convincing the firemen, and often the officials of the logging company, of the necessity of maintaining the screens in perfect condition. One hears of firemen throwing dynamite caps in the firebox to clean out a clogged screen, and it is said that a shotgun is sometimes used for this purpose.

Some fires are caused by missing bolts in the stack or large openings around damper rods.

Efforts have been made from time to time to design boilers with extended fireboxes that would operate with outside exhaust, but except in the case of a large oil-burning outfit, these experiments have not met with success. Blowers operated by exhaust steam have also been tried. By their use approximately the same mean intensity of draft may be maintained without as great a maximum intensity as when the exhaust-steam jets are used. The advantages gained do not seem to warrant the additional cost of the equipment, and the arrester device with its maintenance problems is not eliminated, so this development has not found favor with the operators.

If a design of any kind could be worked out to permit the burning of the present fuels at a high enough rate to satisfy the steam requirements, without the use of the high draft intensity now required, such a design would certainly be welcomed by forest officials and lumbermen alike.

The type of spark arrester using screens frequently clogs and retards the draft, and the engineers and firemen are inclined to use "strong-arm" methods in cleaning them up. This type of arrester is high in first cost, easily damaged, and cannot be inspected without considerable trouble. The type deflecting sparks into water is heavy, requires constant attention, and the scarcity of water in some localities makes its use undesirable. The type using baffles is very heavy to support on the stack, is very likely to offer excessive draft resistance, and has not been developed to a point where it may be considered wholly effective in suppressing dangerous sparks where fuel other than oil is used.

STATE LAWS GOVERNING FIRE-PREVENTION EQUIPMENT ON LOCOMOTIVES AND STATIONARY BOILERS USED IN FOREST AREAS

Under common law, parties responsible for setting fire to woodland are held responsible for all damage done by the fire. This in itself would seem to be a sufficient urge to cause railroads and other operators to properly equip to prevent fire. Some states have no statutes, specifying the preventive measures to be taken (North Carolina, for example), and the others outline the requirements in varying degrees of detail. Spark arresters and spark-tight ashpans are required by law in every case where special equipment is specified. In New York the railroads are required to use oil fuel during the dry season when passing through forest reserves. Fire wardens in several states are empowered to draft any able-bodied man available to help in fire fighting.

CONCLUSIONS

In studying the forest-fire statistics year by year it is very apparent that no substantial gain whatever has been made in the past twelve years in reducing the number of fires or the amount of damage done annually. This statement appears to apply to each individual state in the Union, and to each classification of causes within the state.

It appears that the strenuous efforts of the forestry officials and of the cooperating railroads and lumbering interests have been about offset by our greater industrial activity and our increasing population.

There is no question but that a great amount of constructive work has been done and that large sums of money have been spent on fire-prevention equipment and in educational work directed toward employees and the public, but it is equally apparent that more strenuous efforts must be made if our forests are to be preserved.

Any one who reads the report of the Railroad Forest Protection Conference previously mentioned cannot fail to realize the keen interest taken in the matter of forest protection by all parties concerned. Well-planned meetings such as this should be held in every state where forest protection is of importance, and steps taken to see that the enthusiasm aroused does not die out with adjournment.

Incendiary fire might possibly be checked to some extent by imposing heavier penalties. Practically all state laws define this offence as a misdemeanor and provide a nominal punishment.

Fires due to negligence, which would include campfires, smokers, and brush burning, might be reduced through cooperation with the newspapers, by a still wider use of educational posters, and by enlisting the aid of the various civic and fraternal organizations throughout the country.

The reduction in the number of railroad fires will require large expenditures by the railroads and greater attention to the details of equipment, operation, and maintenance of locomotives operated in forested country. That the self-interest of the railroads should prompt them to take all necessary measures to further this work was brought out conclusively during the Railroad Conference.

The logging operators with large holdings are making every effort to reduce fire risks. The small operator does not always give this matter the attention it deserves, and must be forced or persuaded to lend his cooperation.

The necessity for any concentrated effort to design new spark-arrester equipment or to conduct tests on existing equipment is not at all apparent. Considerable work has already been done

along this line, and if a new arrester could be developed it would be very hard to get it adopted unless it was a very outstanding improvement. The International Railway Fuel Association has a standing committee on front ends which makes a report at each annual meeting of the association, and by following their reports any one interested may keep informed in regard to development in this particular.

The opinion seems to be quite general that if all locomotives are properly equipped with screens of a fine enough mesh to suit the fuel being used, there is very little danger of fire from stack sparks. To get all of the locomotives operating in forest lands properly equipped is a big undertaking, but not an insurmountable one.

To obtain preliminary information for a campaign in this direction would require a little work on the part of a large number of men. The operating data required would include:

1 The kind of fuel used
2 The type of spark-arrester equipment
3 The adequacy of the installation and maintenance
4 Is the netting used of as small a mesh as can be used without interfering with operation?
5 Are the ashpans of spark-tight design?
6 Are ashpans properly maintained?

After the foregoing information is gathered, it would then be necessary to bring all derelict operating companies into line. As regards the railroad this should not be difficult, because when timber burns the railroad loses:

1 The damage claim of the timber owner when the fire is caused by the railroad
2 By the increased cost of railroad timber by reducing the supply along its lines
3 By the loss of revenue of lumber shipments
4 By increased maintenance costs of roadbed and ditches caused by soil eroding from adjacent property
5 By very large periodic losses due to floods which are primarily caused by the barren condition of the upland areas.

Cooling and Lubrication of Cutting Tools

Progress Report No. 1 of the Sub-Committee of Cutting Fluids of the A.S.M.E. Special Research Committee on Cutting of Metals[1]

THE experimental program recommended by the Sub-Committee aims to determine quantitative relations connecting the cutting performance of the fluid in any given process such as finish-turning of steel, with the numerous variables on which it may depend, including not only such factors as speed and depth of cut, but also the physical properties of the fluid, such as its specific heat and its oiliness.

THE PRESENT STATE OF KNOWLEDGE OF THE ACTION OF CUTTING FLUIDS

The superiority of lard oil for such processes as heavy-duty cutting of steel may in all probability be attributed to its function as a lubricant, and especially to its action in lubricating the top surface of the tool directly under the chip.

The superiority of lard and other fatty oils in contrast with mineral oils under high contact pressures is a recognized lubrication phenomenon commonly described by saying that the fatty oils possess the property of "oiliness" in a marked degree. The precise definition and measurement of oiliness constitutes one of the most important problems in the field of lubrication research, and evidently has a very direct bearing on the solution of cutting-fluids problems.

Microscope observations of chip formation conducted by Albert Kingsbury about 1895, showed that when a mild-steel bar is cut by a parting tool in a lathe, a crack in the metal precedes the cutting edge of the tool at all times. As the crack extends, the oil is seen to flow into the crack, the flow being made evident by the motion of minute particles of steel suspended in the oil. Thus the oil is enabled to reach the top surface of the tool, even to the cutting edge. The lubricant is forced into the vacuum in the crack mainly by atmospheric pressure, capillarity probably being secondary if the cutting speed is high. Therefore, if the viscosity of the lubricant is too high, the cracks may not be filled fast enough. It seems very desirable to extend such microscope observations to other materials besides mild steel, and especially to extend them to the finest finishing cuts, in order to determine whether a crack always precedes the point of the tool.

The addition of tallow or any other animal fat to a mineral oil is known to increase its oiliness; experiments would therefore be desirable to determine *how much* the oiliness is increased by adding 15 per cent of tallow, and whether there is any preference among different substances for the die cutting of threads on pipes or bolts provided all substances compared are numerically equal in oiliness.

Milk contains animal fat in suspension, and therefore we should expect to find that it possesses a fair degree of oiliness. It also contains a very high percentage of water, which, because of its high specific heat and low viscosity, constitutes an excellent cooling agent. Thus there is every reason to expect the cutting performance of milk to surpass that of lard oil, mineral oil, or water. Furthermore it is recognized that oiliness is a joint property of the oil together with the metal; very possibly, therefore, the oiliness quality of milk is more pronounced when the milk is in contact with copper than with other metals. Quantitative tests would be very desirable showing definitely *how much* better milk is for cutting copper than the ordinary commercial emulsions, also how much better milk is for copper than for other metals.

When drilling glass and very hard steel it may be more important for the cutting edge to bite than it is to provide a high degree of lubrication; possibly such fluids as kerosene, turpentine, and alcohol function by increasing the coefficient of friction of the rubbing surfaces over and above the value it would have for dry surfaces. If so, these liquids might be classed as negative lubricants, and the concept of the lubrication of cutting tools might be extended to include both positive and negative lubrication.

[1] The personnel of this Sub-Committee consists of Mayo D. Hersey, Washington, D. C., *Chairman;* G. H. Ashman, Schenectady, N. Y.; B. H. Blood, Hartford, Conn.; O. W. Boston, Ann Arbor, Mich.; A. L. De Leeuw, New York, N. Y.; W. Yonkman, Chicago, Ill.; and (ex-officio) W. W. Nichols, Detroit, Mich., *Chairman,* A.S.M.E. Special Research Committee on Cutting of Metals.

Abstract of report presented at the Annual Meeting, New York, December 3 to 7, 1928, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

Further, it has been suggested that the turpentine and other thin liquids may provide a means for the drill to get below a layer of powder formed by the drilling action, where if used dry the cutting edge would roll around on these particles which would act like ball bearings, thus preventing the edge from biting into the uncut surfaces of the glass.

Although actual discovery of what happens at the point of the tool probably lies far in the future, considerable light might be thrown upon the behavior of turpentine by relatively simple experiments in which various ingredients are mixed with the turpentine in small proportions so as to alter its oiliness and other properties by known amounts.

Sulphur is believed to increase the oiliness of lubricating oils, which if so would diminish the friction and therefore the amount of heat released in cutting metal. These facts might be sufficient to account for the superior cutting performance of oils containing sulphur without recourse to its alleged refrigerating effect, but should be tested by quantitative experiments.

A distinction can be made between heat and temperature. The fact that very little heat is generated does not disprove the possibility of considerable temperature rise being localized at the cutting edge. As an illustration of this point, our attention has been called by Dr. H. C. Dickinson to the simple process of scratching a match. Here the work done, and therefore the heat generated, is very minute, but the local temperature rise obviously exceeds the spontaneous ignition temperature of the substance in the head of the match, a matter of several hundred degrees fahrenheit.

The following suggestions have been offered by A. L. De Leeuw, to explain such facts as cannot wholly be accounted for by differences in thermal expansion:

One important function of the lubricant under the chip on the top of the tool, quite independent of its function in reducing the heat generated and in reducing the power consumption, is to insure a steady, uniform back pressure against the chip, thus tending to produce a more uniform diameter and finish.

As the chip comes off in the turning operation, it is repeatedly broken up by shearing action into a kind of echelon formation. Each time the chip breaks or flows, the back pressure on the work is relieved, and obviously the finish produced depends on the nature of this process.

The foregoing hypothesis might be tested by experiments in which the friction on the top of the tool is deliberately increased and decreased over a considerable range. If the same result as regards chip formation, uniformity, size of the finished diameter, etc., is obtained with a high friction on the top of the tool as with a low friction, it would disprove the hypothesis. In order to obtain low friction the top surface of the tool might be given a high degree of polish with the polishing wheel running parallel to the length of the tool. To obtain high friction the tool should be ground with a coarse wheel running transverse to the length of the tool. In these two tests the same lubricant should be employed so that in both experiments the action of the lubricant will be the same in all particulars, except as regards friction on the top of the tool.

Inconsistent results obtained from the use of the same fluids in different plants may be due to the influence of unsuspected variables. For example, the character of an emulsion formed by the use of a soluble oil in water may depend on the local water supply. If soft water is available at one plant and hard water at another, it may be necessary to increase the soap content of the oil to obtain equally satisfactory performance at the latter plant. Closer observation and control of operating conditions in the plants may be required in order to explain the inconsistencies in question, together with quantitative laboratory experiments in which one variable at a time can be investigated.

BUREAU OF STANDARDS RESEARCH PROGRAM

The Special Research Committee on Cutting of Metals at its meeting on December 8, 1926, voted to endorse and finance a program for basic research at the Bureau of Standards, which can be described substantially as follows:

Purpose. To make a beginning on the general problem of correlating performance characteristics of cutting liquids with their physical and chemical properties, with a view to more efficient selection of cutting fluids in machine-shop practice.

Method. (*a*) Experiments on metal cutting to determine relative performance of different liquids quantitatively. (*b*) Study of the physical details of the penetrating action, cooling action, and lubricating action of cutting fluids, including microscope observations. (*c*) Laboratory tests on a series of liquids whose cutting performance is known, including new tests for oiliness, adhesion, and spreading power.

The following are among the items of equipment available at the Bureau of Standards for cutting-fluids research:

1 High-pressure pump and intensifier constructed at Harvard University from the designs of Prof. P. W. Bridgman, capable of developing hydrostatic pressures up to 100,000 lb. per sq. in. and beyond, for use in investigating the viscosity and plasticity of cutting fluids at pressures comparable with those existing under the chip near the edge of a cutting tool.

2 Cutting-fluids friction machine (sometimes referred to as the grooved-specimen machine), designed by Dr. H. C. Dickinson for determining the coefficient of friction and comparative oiliness of different pairs of metals, representing work material and tool material, when lubricated with various cutting fluids under contact pressures that can be varied over a wide range and can be made sufficiently high to cause rapid wear and abrasion of the metal surfaces.

3 Herschel oiliness machine (sometimes referred to as the disk-friction machine) for determining the comparative oiliness of various metal and lubricant combinations at very low speeds, and under loads that are high enough to make the coefficient of friction practically a constant for any one combination of materials, without being high enough to cause abrasion of the polished specimens.

4 Kingsbury oil-testing machine, a vertical-spindle machine by which fairly high bearing pressures can be produced over a known area of contact under conditions favoring "boundary lubrication" as distinguished from fluid-film lubrication. Frictional resistance is measured by the deflection of a torsion wire.

5 Precision thermoelectric equipment for measuring tool temperatures both by the interior thermocouple method and by the tool-work thermocouple.

6 Lathe equipped for research on rough turning by the tool-breakdown method and on finish turning by the leading-and-trailing tool method (the latter comprising two tools rigidly held in the same tool post; cutting performance measured by amount of cutting done before the leading tool dulls sufficiently to bring the second tool into action).

7 Dynamometers of several types.

UNIVERSITY OF MICHIGAN PROGRAM

Experiments on the machinability of metals are being conducted in the Machine Tool Laboratory at the University of Michigan, Ann Arbor, Mich., using among other equipment the following:

1 Planer with specially designed dynamometer

2 Drill equipped for penetration measurements under constant load

3 Drill equipped with dynamometer for torque and thrust measurements

4 Oxford single-tooth milling cutter, pendulum type, providing a measurement of the energy absorbed by the cut.

The study of cutting fluids is closely related to that of machinability. There has been some debate whether comparative machinability values are affected by the choice of cutting fluid. The influence of the cutting fluid must therefore be investigated to determine whether or not it is permissible for machinability ratings to be based upon a dry cut. This investigation will be undertaken at the University of Michigan, utilizing the above equipment.

A second object that can be served at the same time consists in determining whether or not a given series of cutting agents will stand in the same order of sequence when rated by these various types of machinability test.

PRACTICAL SHOP TESTS

After determining by laboratory research under closely controlled conditions what the essential factors governing cutting-fluid performance are, and after mapping out as broadly as possible the relations connecting the different variables, it will be desirable to check the conclusions reached by conducting practical shop tests under quantity-production conditions.

This point of view has been confirmed and very clearly stated in the following letter from one of the largest users of cutting fluids:

In general, we believe that selection of cutting fluids has to be considered in the terms of their basic functions, of which the most important are the cooling, lubrication, washing out chips, and producing a smooth finish. Therefore, our suggestion for a basic research on this subject would be along the following lines:

1 There are at least two major fields to investigate—(*a*) light cutting and (*b*) heavy cutting.

2 We should suggest that a series of preliminary tests be conducted on a suitable lathe or screw machine, equipped to measure (*a*) force exerted upon cutting tools, (*b*) the temperature at the cutting point of tool, and (*c*) power input of the machine used. All factors surrounding the test should be kept constant, and the cutting fluid be the only variable.

3 We suggest that the preliminary tests be followed by a series of confirmatory endurance tests, extending over a longer period of time. Such tests could probably be performed in suitable automatic screw machines or lathes. The quality of the cutting fluid should be measured by (*a*) the life of the tool used, e.g., how many parts a tool will produce before its cutting edge wears off a given amount, (*b*) finish of the product, (*c*) the power required, and (*d*) the size of the work maintained.

We believe that the results of such tests as suggested above could be correlated with the physical and chemical characteristics of the fluids used, and thus be of real value to the industry in general.

SURVEY OF CURRENT PRACTICE IN THE UNITED STATES

An inquiry was sent out to a number of the largest users of cutting fluids in order that our Committee might obtain all possible benefit from the experience of others.

Forty-four replies were received from the leading manufacturers of automotive, steam, and electrical machinery, machine tools, and other products. In general, these contain valuable information and will be kept on file for future reference by the Committee. Extracts from several typical replies are quoted below. From these it will be apparent that very little attempt has been made to conduct *quantitative* research in this field.

As Many Opinions as There Are Venders and Users

Due to the fact that practically all of the cutting fluids on the market at this time are compounded or a blend of various oils and fats, there are about as many views or opinions (as to which is the best) as there are venders and users. However, after a number of years on production work (cutting metal), we have standardized on three types. . .

Work Done So Far Can Hardly Be Dignified as Research

Although we have tried several cutting fluids for the various machining operations we perform. . ., we have not yet reached the point where we are in position to make recommendations based upon our experience. The work we have done so far can hardly be dignified by the designation of research work. We have simply been trying various samples submitted to us by manufacturers, each of whom of course claims his product to be the very best.

Fluid Which Spread the Most Rapidly Gave Best Results

With regard to the practice of selecting cutting fluids, we have based our selection on practical shop tests, extending at times over a period of several months. Our tests were conducted in the following manner:

A cutting fluid was placed in a screw machine running at a constant speed and feed, and producing the same part over an extended period of time. At the same time, other cutting fluids were used in similar machines, and under similar operating conditions. In order to reduce the unaccounted-for variables to a minimum, each cutting fluid tested was used in each one of the machines operated, respectively, the speeds and feeds and the parts produced remaining constant.

The choice of piece part to be run in these tests was usually based on some particular operation to be performed on the part. Some parts afforded a good opportunity to observe thread-cutting operations, others tapping operations, etc.

The tool life and the quality of work produced were taken as a measure of the relative values of the cutting fluids used. The test would usually show up poor oil in a short time. This would manifest itself in the form of broken drills or taps, an excessive number of grindings of tools, and the quality of the work produced.

While we were able to select certain cutting fluids and eliminate others, we have not correlated any of our performance figures with the physical properties of the fluids tested. It appeared, however, that the fluid which spread the most rapidly gave the best result on difficult jobs, such as high-speed turning, drilling, and tapping.

Consumption of Cutting Fluid Cut Down to One-Third

For turning operations and certain classes of milling, we are using a mixture which we prepare ourselves, and this, by the way, is proving very successful in most cases we try. This mixture is prepared as follows: . . .

The result is a white, milky appearing mixture that seems to give us very satisfactory results as far as tool life and finish are concerned. In fact, we have cut our consumption of——cutting oil down to about one-third of what we formerly used and have replaced it with this mixture.

Incidentally, the cost of the foregoing mixture is very much less than the cutting oil formerly used.

As far as we know, there is no real scientific basis for the mixture as given you above. It has rather been the result of a cut-and-try process.

Generous Application of Cutting Fluid Allows Speeding Up Machinery

It is quite difficult to do all kinds of work with one strength of solution, and our experience has taught us not to do it.

Penetration does not enter in the cutting of metals so much as lubrication or cooling, and cooling takes preference, and the application of the cutting fluid should not be made sparingly, but generously and without force. This allows speeding up machinery to greater r.p.m., and in many instances greater feed.

We have never conducted any really extensive research along these lines.

TABULAR METHOD FOR ANALYZING USE OF CUTTING FLUIDS

A chart has been devised as an aid in correlating the information received from the numerous users regarding the selection of cutting fluids for any given operation and material. Copies have been mailed to all companies which replied to the foregoing inquiry, and to a number of others. When the complete returns are available, it is expected that a composite chart can be prepared and a brief report published, analyzing the results obtained.

RECENT EXPERIMENTAL RESULTS

Preliminary results on several problems forming component parts of the Committee's program are briefly summarized below:

Measurement of Cutting-Tool Temperatures. The first experimental work undertaken by the Special Research Committee on Cutting of Metals bearing upon the problem of cooling and lubricating the cutting tool consisted in an investigation of the possibilities of the tool-work thermocouple. Results of this work were briefly published in a paper entitled "Thermoelectric Measurement of Cutting-Tool Temperatures."

Tests on Cutting Oils With the Single-Tooth Milling Cutter. In

an investigation reported to the Sub-Committee, a series of cutting oils were tested by the single-tooth cutter to determine the comparative energy absorbed in cutting the same metal with different fluids. Sixteen fluids were tested, including animal, vegetable, and mineral oils, oleic acid, and various mixtures. The energy values obtained ranged from a minimum of approximately 4.8 with fixed oils or oleic acid, up to a maximum of 7.2 units for certain of the mineral oils. The samples employed have been shipped to the Bureau of Standards for further investigation.

Viscosity and Solidification of Oils Under High Pressure. In coordinating the results of viscosity measurements under high hydrostatic pressure it has been found thus far that both fixed oils and paraffin-base mineral oils solidify or become plastic above certain critical pressures, while no solidification of a naphthene-base oil has yet been observed. On several of these fluids practical shop tests have also been conducted. It seems desirable to extend this investigation to a larger number of oils in order to prove or disprove the suggested correlation between solidification under pressure and cutting performance.

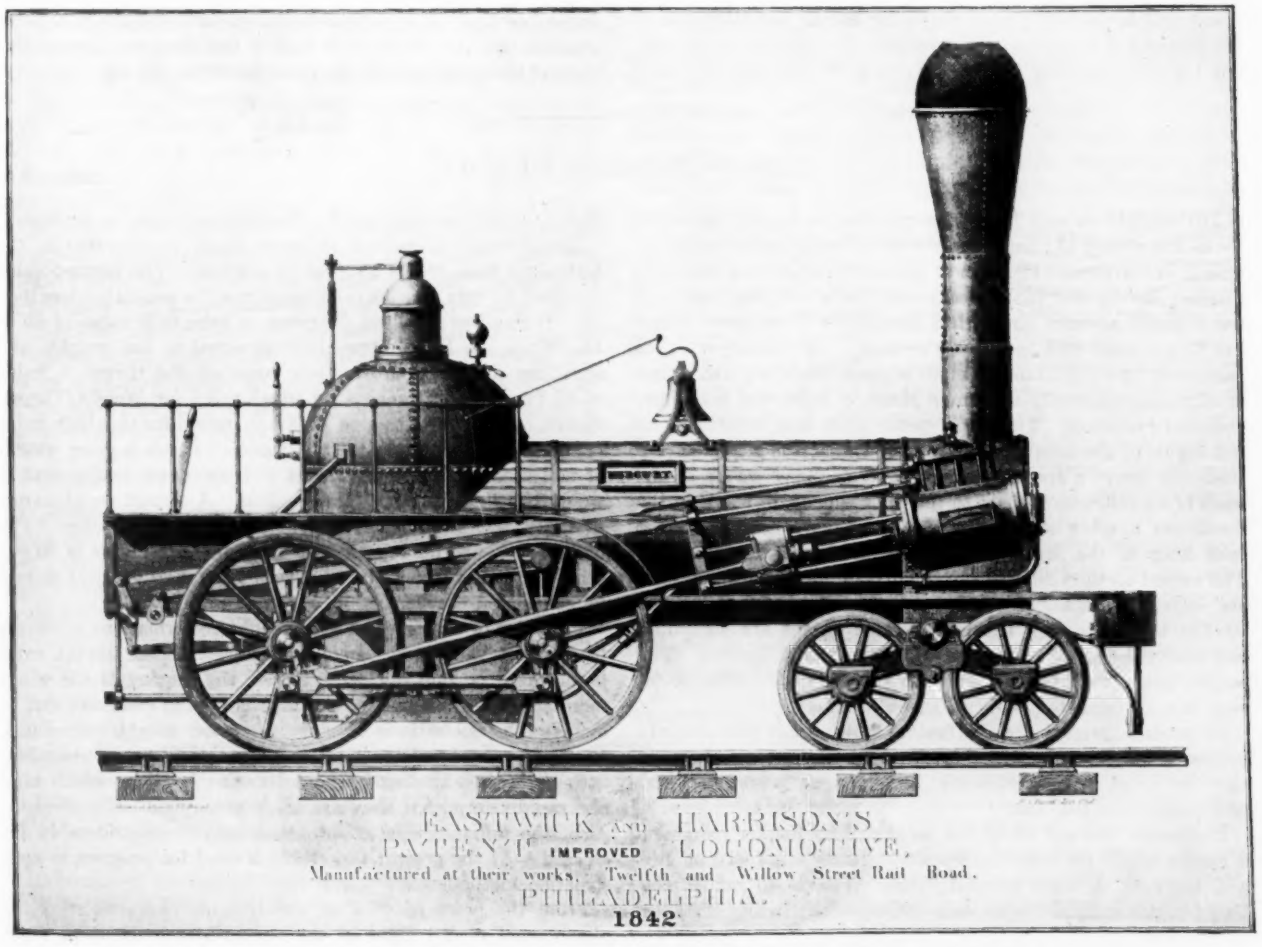
Oiliness Tests. The results thus far obtained by testing a number of cutting oils on the three types of oiliness machines described earlier in this report show that lard oil, oleic acid mixtures, and other fluids generally recognized as efficient cutting agents are also those which give the lowest friction (or highest oiliness) values.

An Early American Locomotive[1]

PRIOR to the year 1837 all locomotives built in the United States or Europe, with one or two exceptions, were provided with but a single pair of driving wheels, following practically the design of the original locomotive of George Stephenson, the *Rocket*, which demonstrated the success of the locomotive in the trials on the Liverpool and Manchester Railway in England in 1829.

It was well understood that a greater tractive power would be obtained by the use of more than one pair of driving wheels, but this involved the distribution of the weight of the engine equally upon all the driving wheels. Several attempts were made to build locomotives with more than one pair of driving wheels,

[1] Contributed by Henry Harrison Suplee, Mem. A.S.M.E., 125 Riverside Drive, New York City.



THE LOCOMOTIVE "MERCURY," BUILT BY EASTWICK & HARRISON IN PHILADELPHIA IN 1842
(Reproduced from a lithograph hanging in the office of the Secretary of the Society.)

notably by Henry R. Campbell in the United States, but these attempts were all made with independent springs over each driving wheel and it was found impracticable to make these springs all of the same stiffness and elasticity, so that the weight could not be equally distributed over the wheels. The wheels over which the stiffest springs were placed carried most of the load and the other wheels performed little or no service, and such engines showed no greater tractive power than the older machines with but a single pair of driving wheels.

In 1837, Joseph Harrison, Jr., of the firm of Eastwick and Harrison, Philadelphia, invented and patented a construction using an equalizing lever on each side of the locomotive, the springs being placed under the center of this lever and the load transmitted to the driving wheels at each end of this equalizing lever. This at once solved the problem by equalizing the load upon all the driving wheels, with the result of greatly increasing the tractive power of the engine.

The first locomotive of this type was built in 1837 by Messrs. Eastwick and Harrison and was called the *Hercules*, the construction being practically identical with that shown in the accompanying reproduction of a lithograph of the *Mercury* which was built in 1842. The performance of these engines attracted the attention of certain engineers who had been sent to America by Emperor Nicholas I of Russia, with the result that Mr. Harrison received a contract from the Russian government for the complete equipment of the Russian railway system then beginning with the railway between St. Petersburg and Moscow, with the result that he left the United States for Russia and discontinued the building of locomotives in America. He disposed of the patent for the equalizing lever to Matthew W. Baldwin who had already started the Baldwin Locomotive Works in Philadelphia, but who up to that time had constructed engines with only a single pair of driving wheels.

This invention of the equalizing lever is the one outstanding improvement in the locomotive since the construction of the *Rocket* in 1829, and it has persisted down to the present time in all locomotives built in any part of the world. For this reason this original lithograph forms a valuable historical relic in the work of mechanical engineers.

This lithograph of the *Mercury* shows also an interesting element of construction in connection with the method of reversing the engine. This reversing device invented by Mr. Eastwick consisted of a thick block of cast iron interposed between the slide valve and the ports of the cylinder. In this block there were formed two pairs of passages, one pair passing straight through, the other pair passing into the block, crossing over diagonally, and emerging on the lower face at the opposite end from that of entrance. When this block was in such a position that the ports passing straight through were in line with the cylinder ports, the engine ran in the forward direction; when the block was shifted so that the cross-over ports came in line, the steam was delivered at the opposite ends of the cylinder and the engine ran in the reverse direction. This block was shifted by a separate rod and reverse lever, as clearly indicated in the lithograph. This ingenious construction worked very well but was soon superseded by the link motion now so generally employed.

When it is considered that locomotives of this type were produced less than ten years after the commencement of railway traction, one can realize how rapidly the American locomotive builders took their place in the development of the art.

Long-Distance Flights[1]

PROGRESS in any field of engineering is largely measured by the ability to predict the results of design before construction is undertaken. Progress in electrical engineering has been marked during the past twenty-five years. Within the next ten years it appears likely that the results of airplane design can be predicted with reasonable accuracy. At the present time there exist two important methods of predicting the performance of airplanes, especially maximum range in miles and maximum endurance in hours. The first depends upon data collected from test flights of the completed plane from which it is possible eventually to derive a speed-time curve. This curve serves as the basis of an instruction chart to the pilot which will result in the maximum number of miles per gallon being achieved during each hour of the flight, thereby giving the maximum range. The second method differs from the first only in utilizing designers' estimated data instead of test-flight data for the airplane. At the time of design the performance curves are computed and from them the speed-time curve is eventually derived. The second method will become general as soon as the results of design can be predicted with sufficient accuracy.

Of general interest are the factors which limit the ultimate values of range and endurance. Among the more important may be listed engine efficiency, aerodynamic properties, and problems of construction.

It appears that not much can be gained by further reduction in engine weight per brake horsepower. Increase in fuel economy has, however, a more hopeful future. Efforts to render the Diesel engine suitable for airplane use, especially in long-distance flights, should be encouraged. Results up to now are promising.

Aerodynamic properties are most easily summarized in the Lift/Drag ratio of the airplane as a whole. The highest value obtained to date for this ratio appears to be somewhat less than 15. It requires excellent designing to achieve a value of 10 or 11. Since the lift is approximately equal to the weight, and since the drag is approximately equal to the thrust, a value of 15 for Lift/Drag means an equal value for Weight/Thrust. Hence, an airplane weighing 15,000 lb. would for this high value of the ratio require only 1000 lb. thrust. Hence a given weight of fuel used to supply the thrust will last much longer than it would if a larger thrust were required. A second aerodynamic property of importance is the efficiency of the propeller. The highest value so far reported for long distance flights is 80 per cent. A design which gives between 75 and 80 per cent should be considered excellent.

Problems of construction are encountered when one attempts to improve the aerodynamic properties. If the aspect ratio is increased beyond the value 7 or 8, the bracing of the wings increases rapidly in weight, so that the gain in efficiency due to increased aspect ratio is offset by increased weight. Similarly, efforts to reduce resistance cause serious problems of assembly, fittings, braces, landing gear, and engine cowling, which may rise rapidly in cost if they are made aerodynamically efficient. Also, the difficulties of maintenance may be considerably increased. At the present time there is need for progress in construction methods.

From the point of view of aerodynamic characteristics the phenomenal record flight of the Savoia-Marchetti, S-64, from Italy to Brazil is likely to stand until further progress in engine design and possibly in construction permits greater achievement.

[1] Paper presented by Baldwin M. Woods, Professor of Aerodynamics, University of California, at a meeting of the San Francisco Section of the A.S.M.E., San Francisco, Calif., January 31, 1929.

The Teaching of Advanced Mechanics in Engineering Schools

By S. TIMOSHENKO,[1] ANN ARBOR, MICH.

MODERN industry, as it develops, makes a more and more intensive use of the fundamental sciences in solving engineering problems. Progressive companies have built up elaborate and expensive research departments which are of long standing, especially in the fields of applied physics and chemistry. Substantial support is also given to investigations in the other branches of applied science, and among these the role of mechanics is becoming one of increasing importance.

The dynamics of the rigid body, of fluids and of gases, the theories of elasticity and vibrations, have become essential features of modern engineering design due to the ever-increasing size and peripheral velocities of dynamos and turbines, the increase in size of engineering structures such as bridges, ships, and buildings, and the intensive development of new industries, e.g., the automotive and the aircraft. The old rule: if a part breaks, make it heavier—has lost its general application. The vast amount of accumulated empirical data will not always fit new cases. For these, solutions are being obtained by a more confident use of the theories of mechanics and metallurgy, and of the laboratory methods which progress in the natural and the applied sciences makes possible.

The question arises, "What will be the sources of the man power for these new laboratories in mechanics?" The answer may be predicted by consideration of the situation with reference to industrial physicists and chemists. They are being trained now in the universities, the leading ones maintaining, not only a faculty for the teaching of elementary courses, but also a group of men whose main interest is to develop science and the men to carry it on. It is a fact well known in the industry that it is a much harder task to find a university graduate with a broad knowledge of mechanics than a well-grounded physicist or chemist. In order to get such men the industries have either to import them from abroad, where the situation with reference to mechanics is as thoroughly solved as that here with reference to physics and chemistry, or they have to take over the duties of a university and train the men in fundamentals.

Subjects Studied in One Course in Advanced Mechanics

As an example, we may consider the Westinghouse Mechanical Design School. This school has been in existence for seven years. Each year from ten to fifteen young engineering graduates are admitted to the school, to spend all their working time for half a year on the study of advanced mechanics. The schedule is approximately:

1 The Dynamics of a Rigid Body (20 days)
2 The Theory of Vibration, with applications to such problems as (*a*) balancing of machines, (*b*) calculations of critical speeds of rotors, (*c*) torsional vibrations of shafts, and (*d*) vibration of foundations (20 days)
3 Applied Elasticity—comprising such subjects as (*a*) stress concentration produced at fillets, holes, and sharp corners; (*b*) theory of curved bars; (*c*) stress analysis in rotating machines; and (*d*) stresses in thin plates (24 days)
4 Aerodynamics and ventilation problems (12 days)
5 Hydrodynamical Theory of Friction, with application to bearing design (10 days)
6 Numerical Calculations, and the approximate methods of solution of the differential equations of engineering mechanics (15 days)
7 Metallography, and the mechanical properties of metals (15 days)
8 Thesis, which represents the solution of an actual problem in mechanical design or research.

This is only an example of what other large companies are doing. The need for this training is apparent from the search for such men by companies which have not as yet established similar schools. There is so great a demand for the graduates of the Westinghouse school within the company, that they are promised to the various departments long before graduation. It has developed that the company experiences most of its troubles not from electrical causes but from mechanical ones which may be removed only by the most careful investigation, hence the importance of the most thorough mechanical training. That this training is successful and that these men "deliver the goods" is vouched for by the fact that they are rapidly promoted, so that it is now necessary to hold competitive entrance examinations in the school.

From the foregoing schedule it is clear that the industry fully realizes the practical necessity of training in the fundamental sciences, as well as the lack of sufficient training in this respect on the part of the engineering graduates who come to take up such work.

The Society for the Promotion of Engineering Education has also recognized the need for the development of such courses in the universities. In 1927, summer sessions for teachers of engineering mechanics were organized at Cornell and at the University of Wisconsin, advanced courses were given, and the general opinion was that further development of such courses is highly desirable.

The American Society of Mechanical Engineers has organized the Division of Applied Mechanics, which met for the first time last spring. The purpose of the division is to support research in the various branches of mechanics, applied mathematics in engineering, and technical physics, and to give opportunity for the presentation and publication of scientific work in this field.

Training for Industrial-Laboratory Work Properly the Function of the Universities

The question was raised earlier as to the source of training for work in the industrial laboratories in applied mechanics. The answer is now clear: it is the universities. Just as the departments of physics and chemistry have done previously, so now must those of applied mechanics undertake the building up of research laboratories and staffs of research men who will have the deep personal interest necessary to pass on enthusiasm for this branch of engineering science, and inspiration to widen its horizons. The industry has shown the way, has urgent need of the graduates; the engineering societies have given the

---

[1] Professor of Mechanical Engineering, University of Michigan.

Contributed by the Applied Mechanics Division and presented at the Rochester Meeting, Rochester, N. Y., May 13 to 16, 1929, of The American Society of Mechanical Engineers.

Note: Statements and opinions advanced in papers are to be understood as individual expressions of their authors and not those of the Society.

movement impetus; and it remains for each university to take over its proper role, not only to satisfy the urgent need of the industry, but also to give a base to its own claims of scientific achievement. In considering the practical possibilities of the situation, it will be recognized that in the existing curricula the undergraduate years are so filled up that the only possibilities are (1) the development of elective courses of an advanced type and (2) the establishment of a new curriculum giving the degree of Bachelor of Science (Engineering Mechanics), such that students having the requisite ability and interest may concentrate on the fundamental courses. The first will afford great opportunities leading to post-graduate work for higher degrees, and will be necessary in the preparation of proper teachers of mechanics. The second will make it possible for students to take work of this character while undergraduates. This should be very useful in preparing engineers for research work in the industry, and may be accomplished in the existing four-year schedule. The first two years will be spent in the usual preparatory courses, the remaining time being devoted to studying mechanics and those branches of applied mathematics which are of use in that connection.

This discussion has been largely confined to the industrial importance of the more intensive development of the science of mechanics. From the point of view of pure science, no justification is necessary. Mechanics should be brought to the level of other branches of science in this country.

Advanced Mechanics in the Electrical Industry

The Mechanical Design School of the Westinghouse Electric and Manufacturing Company, Its Inception, Aim, and Curriculum—Selection of Students—Results Obtained

BY J. ORMONDROYD,[1] EAST PITTSBURGH, PA.

FOR six months of each year the Westinghouse Company conducts a school of advanced applied mechanics at its East Pittsburgh plant. The school provides part of the training for the men who go into the mechanical design of the electrical apparatus built by the company.

Under the pressure of economic development, electrical machines have gotten larger and larger, and rotating apparatus is being driven at ever-increasing speeds. The purchaser of electrical machinery wants more power in less space; he is becoming more and more impatient with serious breakdowns, and he is demanding quiet, smooth operation. Electrical development has kept pace with the increasing demand; but the mechanical development of the structures has lagged behind the demand to such an extent that nearly 90 per cent of the field trouble in electrical apparatus is mechanical in nature. The high cost of material and labor makes these troubles intolerable, especially since modern competition renders it impossible to charge field development to the customer.

The problems of mechanical engineering in the nineteenth century involved, for the most part, a knowledge of simple statics and kinematics. The static judgment of designers was developed to a high point of perfection. The entire development of the more intellectual tools of the profession was stifled by the conception "factor of safety." This comfortable and all-embracing idea seemed to render it unnecessary and even undesirable to examine in any great detail the conditions under which structures worked. The twentieth century with its larger structures presented more difficult static problems; with the speeding up of all motions, dynamic problems arose for the first time to confront the mechanical engineer. Before these new conditions "factor of safety" engineering stood helpless. A new dynamic judgment was needed, and is still to be developed.

Mechanical troubles are either due to accidents of poor workmanship (which includes engineering mistakes) or to the more fundamental lack of correct knowledge as to what is happening in the structure. Fundamental failures are due to unknown or neglected forces, to faulty knowledge of the actual stress distribution throughout the members of the structure, and to the improper use of materials. The last really follows from the first two, since our detail knowledge of the physical properties of materials is more complete than our ability to apply that knowledge. In fact, the first reaction to the new problems was the production of better materials. This alone did not solve the problems, and the mechanical engineer was finally driven to the analysis of those unseen and often unmeasurable things, dynamic forces and stress distribution. The problems of lubrication and ventilation have reached the stage where detailed analysis must supplement purely practical experience.

In 1921 G. M. Eaton, then chief mechanical engineer of the Westinghouse Company's East Pittsburgh works, saw that the more complicated modern problems were getting beyond the ability of experience and judgment alone to cope with, and founded the Mechanical Design School for the training of analytical design engineers.

The modern mechanical engineer must go beyond what he sees, feels, and hears, and analysis and the measurements suggested by analysis are his only means of doing this. Analysis is the eye of the mind. Like the physical eye it creates nothing that it sees, but it reveals relationships hidden from the ordinary senses, and guides the actions in the proper direction. The Mechanical Design School was only part of Mr. Eaton's broader program of awakening a more fundamental interest in the mechanical design of electrical apparatus. The ideal set was to produce mechanical designs fully as adequate as the electrical designs to meet the modern demands.

THE AIM OF THE SCHOOL

The school provides part of the training of those men who will later proportion quantitatively the mechanical structures of the electrical machines manufactured by the company. In spite of its name, no attempt is made in the school to teach the detailed

---

[1] Railway Motor Engineering Department, Westinghouse Electric & Mfg. Co.

Contributed by the Applied Mechanics Division and presented at the Rochester Meeting, Rochester, N. Y., May 13 to 16, 1929, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

NOTE: Statements and opinions advanced in papers are to be understood as individual expressions of their authors and not those of the Society.

design of any machine. No school can do that—only actual experience on the specific apparatus in the engineering departments can teach the design of that apparatus. Only those fundamental principles which appear over and over again in all mechanical design are taught. Specific designs are referred to only as illustrations of the fundamental principles. The student is shown how analysis, taking simple experimental physical laws and definitions, with the aid of mathematical logic, creates many new and useful results or combinations of ideas; he is given a faith that rational methods exist for tackling the most complicated mechanical problems. The creation of this faith is important, and seems to be necessary; it does not seem to exist naturally in the mind of the young engineer. The methods and intellectual tools necessary for the solution of most of our modern mechanical problems have existed for a long time. The Design School has for its chief aim the dissemination of this knowledge throughout the engineering departments of the company.

THE CURRICULUM

The subjects discussed in the school are based on the mathematical physics of actual problems which have arisen in the mechanical design of electrical machinery. The courses are not standardized. They remain fixed fundamentally; but each year sees new and different problems used as illustrative material. The problems are presented to the students of the school just as they are presented to the engineers in the design departments. Emphasis is laid almost completely on the analysis which leads to the formulas or methods of solution of the problem, rather than on the mere substitution of numerical values in the formulas found.

The time spent on each subject varies from three to four weeks. About one-tenth of the time is used for lectures on the subject. The remainder is put into the solution of problems. Since the students form a carefully selected group, no rigid discipline is enforced in the school. Each student uses his time as he chooses. The complete solution of every problem proposed is not strictly demanded.

The courses given are briefly outlined below.

1 *Engineering Mathematics.* Algebraic equations, differential and integral calculus, and differential equations. Emphasis is laid upon the approximate numerical and graphical methods of these subjects. The student is impressed with the fact that mathematics really forms an important tool for the mechanical engineer.

2 *Applied Elasticity.* A fundamental study of the stress distribution in structures under the action of given forces. This course goes far beyond the usual course in strength of materials.

3 *Testing Materials.* The methods and results of modern physical testing are thoroughly discussed. Fundamental ideas rather than numerical data are stressed. Theories of strength are included in this course.

4 *Metallurgy.* The metallurgy of ferrous and non-ferrous metals is studied. Special emphasis is laid on the effects of heat treatment on the physical properties of ferrous metals.

5 *Ventilation.* The hydrodynamics of air flow and heat transfer to various cooling media are discussed. This course is of great importance, since future gains in power output of most electrical apparatus lie in improved methods of cooling rather than in further electrical advance.

6 *Lubrication.* The conditions of pressure distribution, surface contact, oil flow, and energy losses in completely lubricated and waste-packed bearings are treated. Properties of various bearing metals are examined.

7 *Dynamics.* The method of "virtual work" for static problems is explained. Newtonian equations of motion and energy methods as applied to mechanical design are discussed.

8 *Vibration.* This important part of dynamics is treated in a fundamental way. The principles of linear and torsional vibration are outlined. Systems of several degrees of freedom are discussed. Methods of calculating critical speeds in machines are developed, and means of curing vibration troubles are explained.

9 *Electrodynamics.* A fundamental study of the forces acting on electrical machine parts due to electrical causes. This subject as a proper study of the mechanical engineer has never received enough emphasis before.

10 *Special Lectures.* Lectures on welded structures, cost analysis, and patent law are sometimes given in the school.

11 *Special Problems.* During the last three weeks of the school each student is given a special problem which has just recently been solved by the engineering department, or is just in the process of being solved. This gives the student a chance to use the knowledge he has just gained, and gives the teacher an idea as to whether the student has really gained any knowledge.

The courses outlined above cannot be exhaustive because of the short time available. The student gets a glimpse of the scientific environment of each subject. He is introduced to its literature. It is surprising how frequently this forms the student's *first* introduction to that literature. The student has been immersed in the all-too-often-neglected mathematical phase of mechanical engineering.

At the end of the school each student writes a frank and complete criticism of each course, of the method of its presentation, and of the man who gave it. The suggestions contained in these criticisms are considered seriously, and they often result in beneficial changes in the handling of certain courses. This free criticism of the school by its students keeps it from stagnating. Needless to say, some of the comments are very stimulating to the teachers.

THE TEACHERS

The teachers in the Design School are engineers actively engaged in research, development, and design work. The problems they present to the students are living problems for them, and they make them real to the students. Most of the teachers are men who frequently publish the results of their engineering studies in the technical and scientific magazines. They are all men who are in constant touch with the field developments of the company. Their lectures are often on problems which are engaging their active attention at the time the lecture is delivered. They are at once teacher and student. The realization on the part of the student that he is studying a problem along with his teacher instead of under his teacher has the effect of making the work vividly interesting to him. Under these conditions, the work in the school never dries up into formal routine. Without straining for the effect, the natural method of teaching is attained in the Design School. The history of the intellectual development of man has always shown that every increase of knowledge, every new science, has come as the result of concrete, real problems either directly presented by nature or raised by the restless curiosity of man himself. This process is repeated in miniature in the Design School. The student sees the reality of the problems, and easily learns the methods of attacking them because he becomes interested.

The teachers in the school are not the same every year. The same men do not always remain available—new men take their places. One fundamental principle guides in the choice of each teacher—he must be a man not only capable of using the ideas he teaches, but he must be able to explain them clearly. These abilities are separate and distinct. They are not always both present in the same man. If a man capable of explaining clearly a given subject is not available, the subject is not taught. A school to be real must be built around men, not courses.

The spirit and form of the teaching in the Design School are chiefly the results of the work of two men, Prof. S. Timoshenko and C. R. Soderberg. It is significant to note that in 1913, when the school began to take on its present form, only one mechanical engineer trained in American schools was found to give any of the courses in the manner considered desirable. All the other teachers were men trained in European schools. At the present time about half the teachers are engineers trained in America, but none of these men received in the engineering schools either the spirit or the matter of the courses they teach.

Selection of Students

Each year several hundred graduates of the technical colleges arrive in East Pittsburgh. They are distributed through the shop sections and test floors. There they see and handle the apparatus made by the company, and at the same time have a chance to decide what type of work they wish to pursue ultimately. After a few months in the shop they indicate their preference as to type of work. The work of the company is so varied that the choice of activity presented to the engineer is very broad. Only a small percentage of the total number is needed for design work. Only those men who have stated a preference for mechanical-design work are considered as candidates for the Design School. The fitness of the candidates presenting themselves is tested by means of simple problems. The problems are real, detail problems that have arisen in the design work of the company. They involve a knowledge of simple statics, statically indeterminate systems, trigonometric and algebraic analysis, and simple physical laws. The student is tested for grasp of principles, general intelligence, interest in analytical work, and personality rather than for the numerical solution of the problems. The solution of the test problems usually takes several weeks' work (done in the student's own time). During this time the student usually has several conferences with the engineers who proposed the problems. It is easy to tell from this extended contact who are the men really interested in analysis and capable of doing the work. The final group consists of from 5 to 12 men. The number in the school will probably increase in the future. Each year one or two electrical engineering graduates are included in the school. It is a matter of interest to note that the electrical graduates always show signs of a better fundamental education than the mechanical graduates.

Results of the School

Graduates of the Design School are doing pioneering mechanical development in many of the engineering departments at East Pittsburgh; some are engaged in similar work at the other plants of the company. These engineers have become familiar with all the general fundamental problems in the design of the company's product; they know intimately the older engineers who have acted as teachers for them. Long after the Design School is over, the students discuss their problems with their former teachers. The entire mechanical engineering activity tends to become a unified activity.

Independently of its ultimate results, the school provides much immediate pleasure for both the student and the teacher. The student feels the intellectual exhilaration of a new atmosphere. He is suddenly treated as if he were mentally mature, and he is tasting the joy of using his reason on real problems. It seems to give him real pleasure to find that mathematics and mathematical physics can actually lead to useful results.

The effect on the teachers themselves is even more beneficial. Many a design problem has only been completely solved after an attempt has been made to explain it to the Design School. Very often ideas half-grasped solve a practical problem, but more than a half-grasp is necessary to present the same problem to the students.

Connection With the University of Pittsburgh

Realizing that cooperation between the schools and industry in the education of engineers was desirable, the University of Pittsburgh and the Westinghouse Company have reached an agreement whereby credits toward post-graduate degrees at the University are given for work in the Design School. Many of the engineering graduates pursue post-graduate work at night in the University of Pittsburgh. In fact, it is astonishing to see the tremendous urge for education that stirs these so-called "flaming youths" just out of college. Practically every one of the several hundred student engineers at the Westinghouse Company is spending one or more nights each week attending lectures either at the University or at the Westinghouse Club. This activity is completely voluntary, and not done from hope of immediate reward. The standing of the young engineer in the company does not depend in any formal way on the attendance to lectures.

General Comment on the Education of Mechanical Engineers

Is the existence of the Design School a challenge to the engineering schools, or is it a natural thing for an industry to supply its own engineers with more or less theoretical training? The necessity for the school indicates a lack of something in the engineering graduate which is considered desirable. Is the education of the mechanical engineer being spread too thin? As was mentioned before, the electrical graduate seems on the average to be more at home with the fundamental intellectual tools of his profession than the mechanical graduate.

The American Society of Mechanical Engineers has recognized the importance of cultivating the theoretical side of mechanical engineering by instituting the Applied Mechanics Division. The same recognition is being shown at the University of Michigan, which is including in its next summer school several intensive courses in advanced theoretical mechanics with special reference to engineering problems.

Although the students of the Westinghouse Design School are carefully selected, the ease with which they grasp the ideas handled in the school indicates that advanced mechanics need not be considered too deep for engineering undergraduates. The problems of modern machine design emphatically demand a deeper knowledge of actual conditions than the usual course in strength of materials provides. It is inevitable that the mechanical engineering schools must give over more and more of their future curricula to pure mathematics and mathematical physics. These things have ceased being intellectual luxuries—they have become economic necessities.

Discussion

BETTER and more extended training in mechanics was considered essential by all of the speakers who discussed the papers of Messrs. Timoshenko and Ormondroyd on advanced mechanics. Some differences of opinion existed as to the best methods of providing the necessary training. The establishment of special undergraduate courses in mechanics, provision of more time in the curriculum for instruction in mechanics, increased graduate study of the subject, special training by large industries with men chosen from their own organization and the sending of selected men to summer schools for desired training, were some suggestions advanced.

The opinion was also put forward that but few engineering graduates had particular need for advanced training in mechanics, and that all students of engineering or even a majority of them should not be required to take additional courses. Selected students should be encouraged to do advanced work, and proper courses provided for them. Specialization in mechanics should

be carried out in graduate work, and facilities for experimental work should be provided. Men with special advanced training in mechanics should be able to solve important research problems, and do fundamental work that would make money for employers. A man of this sort naturally could command a high salary.

That the subject of advanced mechanics is quite fundamental and important in a general field was voiced by F. E. Turneaure, dean of the college of mechanical engineering at the University of Wisconsin. He said that in the field of civil engineering, advanced mechanics and structural theory had been offered for many years, and a considerable group of students, both undergraduates and graduates, had received sufficient training in school to enable them readily to develop any further information needed in structural problems. This advanced work was generally arranged as elective courses for seniors and graduates, and the opportunities offered had been adequate. He favored making similar provisions for mechanical and electrical engineers.

H. P. Hammond, associate director of the Society for the Promotion of Engineering Education, felt that the principles of mechanics were so fundamental that they should be dwelt upon constantly, and be understood so thoroughly by the student as to be a real part of his mental equipment. He said that more time should be provided in the curriculum for instruction in mechanics for all engineering students. This would not only permit of more advanced work, but give a more thorough and fundamental training. Further, something could be done through recruitment and training of better teachers. The speaker favored extending the study of analytical mechanics over two semesters instead of one, and the devoting of more time to the study of dynamics.

Plans of the Harvard Engineering School to offer to mechanical engineers such subjects as balancing, the gyroscope, theory of brake design, hydrodynamic theory of lubrication and bearings, and stresses in high-speed rotors due to centrifugal forces were outlined by Arthur E. Norton, assistant professor of mechanical engineering at the Harvard Engineering School. Parts of these subjects could be taken by fourth-year students and part of them reserved for graduate work. If, however, mechanical design, especially the problem of vibration, was to be carried to a high point, graduate work in the basic physical theory must become more common. He felt that some method should be found by which schools and industries together could collect data on important design problems. These data could then be organized into "cases" for graduate students. It was the case system, he said, which had revolutionized the teaching of law several years ago, and it was now being applied to the teaching of business administration with great success. Small industrial companies should send promising young engineers back to schools offering graduate work for intensive study of advanced mechanics and applied mathematics, just as the Army sends officers to special service schools.

Demands on college curricula were increasing, said E. F. Church, Jr., professor of mechanical engineering at the Polytechnic Institute of Brooklyn, but most colleges were prepared for it. Large industries could give any special training required to men selected from their own organizations with very little trouble. Industries in large cities, he said, could arrange with educational institutions in their neighborhood for special courses to be given by members of regular college staffs in evenings or late afternoons. Small industries needing men with special technical training could afford to send men from their staffs to summer courses. He felt that education in advanced mechanics should be limited, and that general engineering education should not be complicated by inserting specialties at the expense of other important subjects in the college curriculum.

The engineer was a doer and creator, said N. D. Hubbell, of the department of industrial economy, Eastman Kodak Company, and dealt with the design and erection of concrete objects. In this work he applied fundamental principles which had been worked out by painstaking research. The type of man who throve on tedious research work of a highly scientific nature was entirely different from the practical engineer who was creating, designing, and building.

There was, he said, a scarcity of young men for research engineering work, a lack of interest on the part of young engineering graduates in research as a life field, and an inadequacy of training for this work by the average engineering graduate. From a vocational-guidance viewpoint it was surprising that we got as many as we did from our present system, which furnished us only those who were research scientists at heart, and got into engineering by mistake without correcting the mistake until after graduation.

The man who would be a "first rater" in practical engineering and also a "first rater" in research in higher mechanics would be an enigma, because many of the qualifications for the two fields were opposed.

There were at present many indications that engineering schools were ready to follow the requirements of industry, said G. B. Karelitz, of the research department, Westinghouse Electric & Manufacturing Company. Observation of conditions showed that the system of education always lagged behind life. If analytical mechanical engineering was needed, the schools would no doubt change their curricula to satisfy the demand.

Naturally it would take some time to change the whole system of teaching mechanics; this would require, in the first place, new textbooks, and, probably, new demonstration and laboratory equipment. Meantime a course of applied dynamics might be added to the existing material. The course would treat the questions most often met by a mechanical engineer in his activities. It might tentatively consist of the following subjects: Principle of virtual displacement and its application to statical problems and to moving kinematical systems; path of points; velocities and accelerations in a mechanism; simpler vibration problems; balancing of rotary and reciprocating engines; principles of momentum and work; rotation of rigid bodies, gyroscopic effect; general theory of governing of machines; impact; instantaneous stresses.

Burt L. Newkirk, engineer in the research laboratory of the General Electric Company, Schenectady, N. Y., did not favor requiring all students in engineering, or even a majority of them, to take additional courses in mechanics, but felt that selected students should be encouraged to do advanced work, and that facilities for such work should be provided.

Specialization in mechanics must be carried out in graduate work. Other professions, he said, require graduate study, and it seemed reasonable that men who expected to do high-grade work in the engineering profession should spend some time in graduate study. Classes in mechanics might be organized among the instructors who were teaching mathematics and mechanics. In each of our larger universities there were something like 50 persons teaching classes in mathematics or mechanics. Of course not all of these would be interested in mechanics, but a few of them would be, and such persons might be organized into classes for special advanced work in mechanics. Facilities for experimental work should be provided, and it was essential that experiments go hand in hand with theory.

There should be no difficulty in getting higher salaries for the men who were prepared to do high-grade work on mechanical problems. The selected individual with special advanced training in mechanics should be able to solve important problems and do fundamental research that would make money for his employer, and a man of this sort could naturally command considerably more than ordinary compensation.

SURVEY OF ENGINEERING PROGRESS

A Review of Attainment in Mechanical Engineering and Related Fields

The Most Economical Steam Pressure for Central Stations, Assuming the Use of the Löffler Boiler

THIS is a continuation of a paper, the first part of which was abstracted in the June issue of MECHANICAL ENGINEERING, pp. 459–461.

FIRST COSTS OF THE INSTALLATION

Costs of Conventional Boiler. It is assumed that up to pressures of 30 atmos. the boiler drums have riveted heads, while in boilers at pressures from 30 to 50 atmos. welded drums with crimped-on heads are used, and for still higher pressures, forged drums with crimped-on heads. The proportions of the boilers are such that their efficiency and the preheating of the combustion air to 350 deg. cent. (662 deg. fahr.) are the same at all pressures. The economizers are designed for preheating of feedwater to about 40 deg. cent. (104 deg. fahr.). In order to arrive at costs about which there will be no question, the following two assumptions have to be satisfied: (1) The individual heating surfaces have to be most favorably proportioned for all pressures, and (2) all costs have to be calculated in the same manner and on the basis of the same prices.

Bids made by various boiler concerns, when it comes to proportioning the heating areas, often pay too little attention to the influence of the higher steam pressures. Not infrequently very nearly the same dimensions are offered for the same electric output at 20 and 50 atmos. boiler pressure, which, of course, is quite wrong. In order to avoid confusion in this work the author has laid down the rule that as long as nothing is said to the contrary, boiler prices shall be based not on the same outputs of steam but on the same electrical outputs, measured on the low-pressure side.

Formerly in calculating heating surfaces merely estimates were used. No adequate attention was given to the influence of higher saturation temperatures, varying dimensions of combustion space, degree of preheating of the air of combustion, subdivision of boiler heating surfaces into radiation and conduction surfaces, etc. The author has, however, recently worked out a method by means of which (using curve 5 in Fig. 1 (MECHANICAL ENGINEERING, June, 1929, p. 459), he can compute the individual heating surfaces (boiler, superheater, economizer, air preheater) for pressures from 16 to 140 atmos. and for useful electrical outputs of 24,000 to 30,000 kw., assuming fresh-water cooling. This is given herewith in Fig. 1.

The air-preheater heating surfaces become less with increasing pressure as the specific fuel consumption falls off; on the other hand, the economizer heating surfaces increase as the inlet and outlet temperatures of the feedwater rise as a result of preheating through bled turbine steam. In all cases, however, the temperature of the exhaust gases, temperature of the combustion space, and coefficient of cooling remain the same. The specific combustion-space load is about 15 per cent greater at 140 atmos. pressure than at 16 atmos., because as a result of the use of a small combustion space, the combustion-space temperature usually becomes lower than 1350 deg. cent. (2462 deg. fahr.). As a result of all of this the high steam pressures fall off somewhat too favorably, which may, however, be neglected as the whole tendency in computation is to take a view favorable to the higher pressures in all doubtful cases.

For certain kinds of coal and depending on the character of the load curve, it may be desirable to augment the individual values shown in Fig. 1. Since these, however, do not depend on the boiler pressure, they may be neglected for purposes of present comparison. The general conclusion to which the author comes is that the heating surfaces of modern boilers

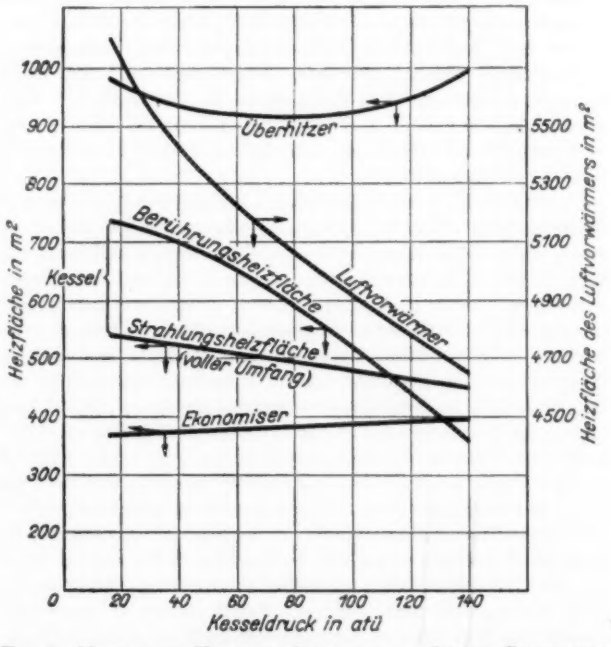


FIG. 1 NECESSARY HEATING AREA FOR A STEAM GENERATOR WITH FRESH-WATER COOLING TO PRODUCE 24,000 TO 30,000 KW.

(*Heizfläche in m²* = heating area in square meters. *Heizfläche des Luftvorwärmers in m²* = heating area of air preheater in square meters. *Kesseldruck in atü* = boiler pressure in atmospheres gage. *Überhitzer* = superheater. *Luftvorwärmer* = air preheater. *Berührungsheizfläche* = conduction heating surface. *Strahlungsheizfläche (voller umfang)* = radiation heating surface (total). *Kessel* = boiler. *Ekonomiser* = economizer.)

with their high loads per unit of heating area must be comparatively extensive, the more so the higher the boiler pressure. He considers in detail the costs of conventional boilers and those of the Löffler boiler. It is the latter that is of particular interest here.

The author points out that it is difficult to determine precisely the manufacturing cost of the Löffler boilers as hitherto only a few of them have been built, and in estimating costs no effort was made to compute them on the same basis of cost for materials and labor as in the manufacture of conventional boilers. However, since their heating surfaces consist entirely of superheater units, a comparison with ordinary equipment

costs has been made by computing their cost in terms of superheater cost in accordance with the data of Fig. 2.

For highly stressed parts certain extras were allowed as compared with usual superheater elements, while the costs of the collector, fittings, piping, and masonry were computed in the same way as on standard boilers. The cost of the circulating

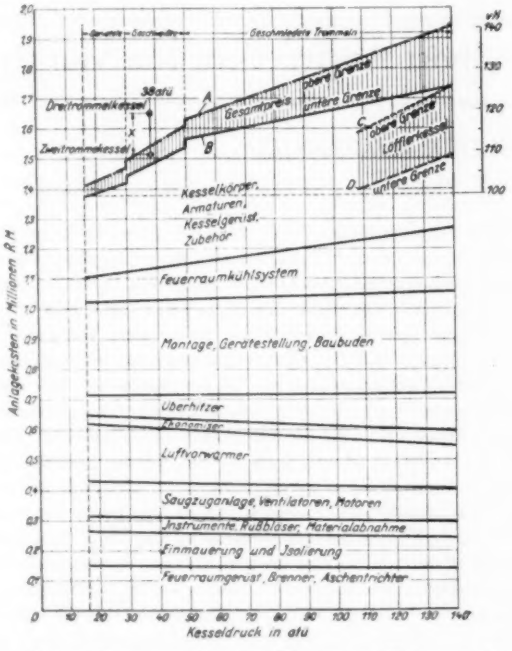


FIG. 2 FIRST COST PER SQUARE METER OF HEATING SURFACE AS A FUNCTION OF BOILER PRESSURE

(*Anlagekosten Mark/m² Heizfläche* = first cost in marks per square meter of heating surface. *Kesseldruck in atü* = boiler pressure in atmospheres gage. *Kühlfläche (volle Oberfläche)* = cooling area (total surface). *Tatsächlich benötigt* = actual required. *Kesselheizfläche* = boiler heating surface. *maximal unter* = maximum possible. *Überhitzer* = superheater. *Ekonomiser* = economizer. *Genietete* = riveted. *Geschweisste* = welded. *Geschmiedete trommeln* = forged drums. *Luftvorwärmer* = air preheater.)

pump and its drive was obtained through a quotation made by a concern not otherwise interested in the matter.

Curves *C* and *D* in Fig. 3 show the upper and lower limits of costs of a Löffler boiler operating with 350 deg. cent. (662 deg. fahr.) warm-air temperature, having a load on the combustion chamber of 200,000 to 250,000 kg-cal. per cu. m. per hr. (22,500 to 28,000 B.t.u. per cu. ft. per hr.) and an output of 24,000 to 30,000 kw. The cost figures vary between *C* and *D*, depending on the size of the collector and cost of the ground area occupied. For purposes of estimates of commercial possibilities, the lower prices (curve *D*) have been assumed, just as was done in the case of the conventional boiler. Further data would indicate that the cost estimate shown in Fig. 3, curve *D*, on the Löffler boiler is reliable. It would appear, therefore, that the Löffler boiler, including circulating pump and drive, can be built at approximately the same cost as a thermally well-designed two-drum boiler working at 35 to 45 deg. atmos. gage pressure, or a three-drum boiler of the usual dimensions and furnace load for 30 atmos. gage. The idea that the cost of the circulating pump brings the price of the Löffler boiler above that of the conventional boiler is incorrect.

TOTAL COSTS OF THE PLANT

Considering everything, it would appear that the difference in the first cost of plant in so far as it is affected by the selection of the boiler and pressure, varies from 3.5 to 6 per cent. The first cost of the central station may therefore be materially reduced by the proper boiler design. From Figs. 4 and 5 it would appear that by especially skilful proportioning and construction of water-tube boilers the cost of a large central-station operating with 100 atmos. pressure as compared with one operating with 35 atmos. pressure, both employing fresh-water cooling, may be from 7 to 9 per cent lower, and in the case of recooling, from 6 to 7 per cent lower. When, however, boilers with multiple drums are employed, the additional costs may under certain conditions be considerably higher—from 10 to 12 per cent in one case, and from 9 to 10 per cent in another (points A_1 and A_2 in Figs. 4 and 5). In the most favorable case a plant with

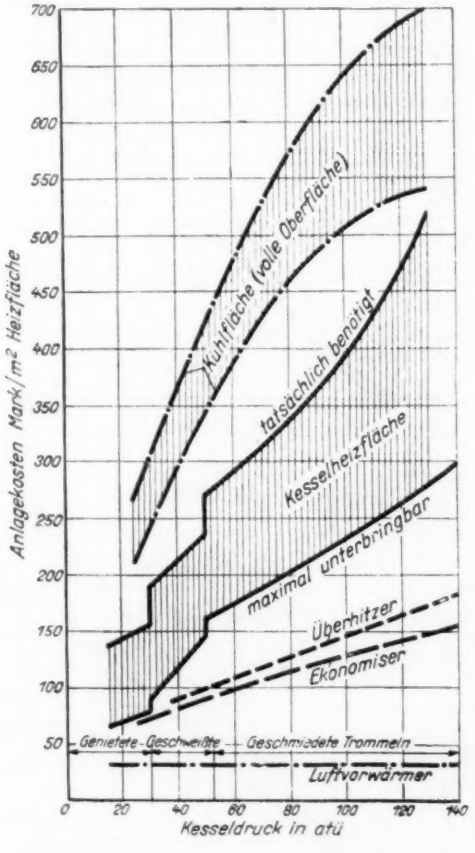


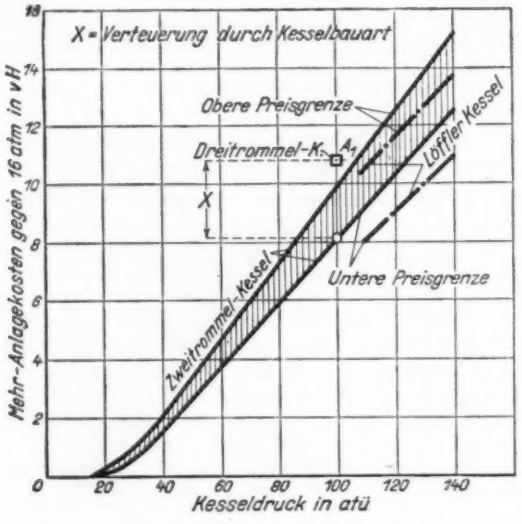
FIG. 3 COSTS OF STEAM GENERATOR WITH FRESH-WATER COOLING AND A USEFUL OUTPUT OF 24,000 TO 30,000 KW. AS A FUNCTION OF BOILER PRESSURE

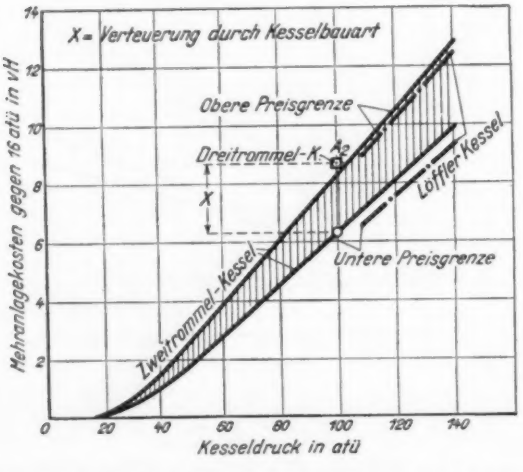
(*Anlagekosten in Millionen R.M.* = first cost in millions of Reichs marks. *Kesseldruck in atü* = boiler pressure in atmospheres gage. *Genietete, Geschweisste* = riveted, welded. *Geschmiedete Trommeln* = riveted drums. *Dreitrommelkessel* = three-drum boiler. *Zweitrommelkessel* = two-drum boiler. *Gesamtpreis obere Grenze* = total price, upper limit. *Gesamtpreis untere Grenze* = total price, lower limit. *Löfflerkessel* = Löffler boiler. *Kesselkörper* = body of boiler. *Armaturen* = fittings. *Kesselgerüst* = boiler auxiliaries. *Zubehor* = equipment. *Feuerraumkühlsystem* = firing chamber cooling system. *Montage, Geratestellung* = installation and placing of equipment. *Überhitzer* = superheater. *Ekonomiser* = economizer. *Luftvorwärmer* = air preheater. *Saugzuganlage, Ventilatoren, Motoren* = suction plant, fans, motors. *Instrumente, Russbläser, Materialabnahme* = instruments, soot blowers, waste removal. *Einmauerung und Isolierung* = masonry and insulation. *Feuerraumgerüst, Brenner, Aschentrichter* = firing chamber equipment, burners, ash delivery.)

Löffler boilers will be about 2 per cent cheaper than one with exceptionally well-designed two-drum boilers designed for the same pressure. The saving in total cost due to the employment of Löffler boilers is therefore not as great as one might assume from a consideration of boiler costs proper only, as shown by curves in Fig. 3. This is due to the fact that the power consumption of the auxiliaries in the Löffler boiler is 2.5 per cent higher. In this case the author considers the reasons for a

greater cost of plants employing recooling as compared with those employing fresh-water cooling. He also points out that the extra power consumption of the individual boilers must be kept as low as possible, because in addition to being a constant cause of increased consumption of coal, it results in an increase in the apparatus required and hence in an increase in cost of the entire power plant.

The author considers as the most important factor brought





Figs. 4 and 5 Extra First Cost (in Per Cent) of a Central Station as Compared With One Working at 17 Atmos. Abs.

(*Mehr-Anlagekosten gegen 16 atm in vH* = extra first cost as compared with 16-atmos. units in per cent. *X* = *Verteurung durch Kesselbauart* = *X* = increase of cost due to change in boiler type. *Obere Preisgrenze* = upper price limit. *Dreitrommel-K* = three-drum boiler. *Zweitrommel-Kessel* = two-drum boiler. *Löffler Kessel* = Löffler boiler. *Untere Preisgrenze* = lower price limit. *Kesseldruck in atü* = boiler pressure in atmospheres. *Bei Frischwasserkühlung* = with fresh-water cooling. *Bei Ruckkühlung* = with recooling.)

out by the present computation the fact that with proper construction and properly selected machinery the costs of a power plant of a given effective output, working with a boiler pressure of 100 atmos. as compared with the cost of a similar plant working with 40 atmos. under specially favorable conditions, is essentially the same and may vary only to the extent to which quotations made by different manufacturers are apt to vary. There is therefore no need to be surprised when in individual instances a 100-atmos.-pressure plant may cost but little more than one of 40 atmos. (Friedrich Münzinger in a paper presented at the fourth meeting of the Commission for the Investigation of High-Pressure Steam Plants of the Association of Central Stations in Germany, Mannheim, Feb. 22–23, 1929. Abstracted from reprint of Proceedings to be published in a German technical journal at a later date, 23 pp., 26 figs., The part abstracted here comprises pp. 6 to 14)

Short Abstracts of the Month

APPLIED MECHANICS

The Science of the Phenomena of Flow

THE present discussion by Prandtl is based largely on his own work and the work of his associates at Göttingen. Particular attention is being paid there at present to turbulent fluid motion. In the majority of cases of technical flow its character is turbulent, and it is therefore very important to determine the quantitative laws of this kind of flow in order to make possible its calculation. An important step forward was the formulation of the frictional forces produced by a motion of a mixed character. In the formulation it was found that in accordance with previous observations the resistances are proportional to the square of the velocity.

Of considerable importance also are the magnitudes of the paths traveled by individual particles of the liquid in the course of "mixed" motions. The laws as to the distribution of these "mixed paths" are being now determined from turbulent motions of the most varied character. In cases where this distribution of particles could be predicted in a simple manner, a very good accord was found to exist between the calculated distribution of velocities and that observed. Of great importance are the turbulent processes occurring in the frictional layers created during the longitudinal flow of a liquid along a wall or surface of a body. It is not only the friction of the surface layer that is affected thereby (and, for example, in the case of marine vessels and airships this constitutes the predominant part of the total resistance), but the character of the entire flow is affected. It is only because this frictional layer is subject to turbulent motion that flow phenomena characterized by small resistance and large amount of drive become possible; they are made use of in connection with airships, propellers, etc. The point in this case is that the flow closes up again as completely as possible behind the body in question, and it is only through the assistance of turbulence that this happens. Turbulence, therefore, which usually is considered as an unwelcome phenomenon because of its tendency to increase all resistances, is in this case very helpful to the engineer.

An entirely separate question is that dealing with the origin of turbulence. For a long time this remained fairly obscure, and comparatively little progress has been made since the calculations of Osborne Reynolds. Effort was directed toward finding a form of oscillation which, beginning with small disturbances, increased with time. Actually it was found that such oscillations as arose slowly decreased with time through the action of friction. In this connection Prandtl announced a discovery by stating that he had succeeded in producing oscillations of a different form, namely, the kind that arose through friction against a wall in the case of longitudinal flow, but which showed an increase in amplitude. It can be said now, therefore, that the explanation of the origin of turbulence has been found. (Address by Dr. Prandtl before the Scientific Board of the Verein Deutscher Ingenieure, Apr. 12, 1929, abstracted through *Zeitschrift des Vereines deutscher Ingenieure*, vol. 73, no. 24, June 15, 1929, p. 837, *etA*)

AUTOMOBILE ENGINEERING

The Salerni Transmission Coupling

THIS coupling is being introduced by a company in England and is intended to be located between the gear set and the front joint of the propeller shaft. It consists of an ordinary dog clutch, between the two members of which is interposed a floating ring, the function of the latter being to prevent the dog members from reengaging one another unless they rotate at precisely identical speeds. When the engine clutch is disengaged fully, the dog-clutch units are withdrawn from one another, and the ring is immediately turned to a position where it acts as a distance piece between the dog members, the latter then being prevented from interengaging. The transmission line is thus "broken," the car is brought to a coasting condition, the gear set is isolated, and, consequently, the gears can be changed easily and silently.

When the engine clutch is reengaged and the engine is accelerated to take up the drive, the effect is to speed up the transmission driveshaft. As soon as the latter, which carries one unit of the dog clutch, reaches the exact rotational speed of the shaft carrying the other unit (the propeller shaft), the "synchronizer ring" is rocked in the reverse direction to its previous movement relatively to the units of the dog clutch and brought into its original position, so allowing the dog members to reengage automatically.

When the coupling is engaged normally, the driving and driven dogs are interlocked, and so also are the dog teeth of the ring and the outer ones of the driven member. If a change of gear is to be made, the clutch pedal is depressed fully (partial depression will not suffice); the link between the pedal and the coupling then causes the driving-dog member to be drawn forward away from the driven member, and the two main units are free to rotate at different speeds. When the driving and driven dogs are separated the frictional contact between the ring and its flange abutment and boss tends to cause the ring to move with and at the same speed as the driving member; but it cannot move far relatively to the projections or minor dogs on the driven unit; the latter carry the ring around with them, and it then rotates freely on the driving member.

The change of gear can then be made easily, irrespective of engine speed or road speed; alternatively, the clutch pedal can be released and the car will coast with the original gear engaged. (M. W. Bourdon, *Automotive Industries*, vol. 60, no. 20, May 18, 1929, pp. 768–769, 1 fig., *d*)

ENGINEERING MATERIALS

A New Type of Machine Bronze

THIS article deals with low-tin-bearing bronzes which can be hot rolled, forged, and extruded.

The ordinary machine bronzes cannot be hot worked. It is nearly impossible to hot work a bronze with 5 to 17 per cent of tin, and consequently we may not produce wear-resistant articles from hot-worked tin bronzes. The application of the latter is therefore strictly limited to the cast state with its inferior strength and frequently a doubtful soundness. If, however, we go beyond 17 per cent of tin the alloys become well workable hot. With this amount of tin they represent mainly the beta constituent, and this phase is rather plastic when hot in practically every copper-alloy system known. On the other hand, the beta bronze does not stay stable, and on dissociating, at about 510 deg. cent., it develops an excessive amount of the hard delta. For this reason a bronze of this kind has too little strength and plasticity in the cold state and cannot be used for machine parts. In addition its price is too high. A group of alloys which work well in the hot state are the beta brasses. These contain from about 33 to 53 per cent zinc at a temperature of 700 deg. cent., and only 44 to 49 per cent in the cold state. An alloy with, say, 41 per cent zinc when worked hot and cooled down represents a mixture of alpha and beta brasses. The field of their application is enormous (yellow brass), but the hardness difference between alpha and beta (50 and 100 Brinell, respectively) is too small and the texture too dense. For these two reasons their ability to act as wear-resistant machine parts is rather mediocre.

The author analyzed the metallurgical conditions which produced the above results and found that in order to produce the kind of material that he wants it should contain no beta brasses but should have a properly adjusted and distributed amount of delta brasses. He did actually produce a brass in which delta nearly predominates and forms a continuous network, with the alpha brass present in the shape of islands. When cooled this alloy is too brittle to be useful. However, an illustration in the original article shows the structure of a heat-treated forging, which appears to be very good. (M. G. Corson in the *Metal Industry*, vol. 27, no. 6, June, 1929, pp. 278–279, *d*)

Diphenyl Manufacture on a Commercial Scale

DIPHENYL ($C_6H_5)_2$ in the past was one of the rare organic compounds priced at about $40 per lb. It is valuable as a heat-transfer medium to be used in the vapor phase as it is non-corrosive and stable at temperatures around 800 deg. fahr., with a sufficiently high boiling point to permit condensation and circulatory reheating with minimum loss of energy in continuous operation. Methods of manufacture have been developed by the Swann Corporation with the result that it is now a commercial product available in carload lots at 40 cents a pound. Diphenyl melts at 70 deg. cent. (158 deg. fahr.) and boils at 254 deg. cent. (490 deg. fahr.).[1] The material is produced from benzol, a by-product of coke manufacture. Some of the details are not disclosed. It is stated that a number of derivatives of diphenyl with an important industrial application have been also developed. (*Manufacturers Record*, vol. 95, no. 20, May 16, 1929, pp. 58–59, 1 fig., *g*)

FUELS AND FIRING (See also Power-Plant Engineering: Powdered-Fuel Firing by Pregasification)

Classification of Coal

A LITTLE more than two years ago a meeting of representatives of various professional societies and organizations was held in Pittsburgh to consider what action, if any, should be taken on the classification of North American coals.

The U. S. Geologic Survey confines itself to the proximate analysis and calorific value of coal, together with certain physical properties.

The Sub-Committee on Methods of Analysis is, among other things, developing an accelerated slacking test for low-rank coals and lignites (described in the original report).

The Sub-Committee on Proposed Systems of Classification has under consideration and is now engaged in their correlation.

In summarizing the program of the Sectional Committee, the following is kept in mind:

1 Coal should be classified primarily on the basis of its intrinsic chemical and physical properties. These properties involve the origin, composition, and construction of the coal.

[1] It would appear that diphenyl has approximately the same melting and boiling points as the diphenyl oxide referred to in the paper by H. H. Dow in MECHANICAL ENGINEERING, vol. 49, no. 8, August, 1926, pp. 815–818.

2 Use classification should be secondary to scientific classification and should be correlated with the scientific classification as far as possible.

3 Scientific classification depends on two primary factors: First, the composition and type of the original coal-forming vegetation, and second, the degree of metamorphism or coalification of the vegetable residue.

4 The first factor is described broadly in the type of the coal, as xyloid, anneloid, or boghead; the second factor, in the progressive rank of the coal as expressed in the series from lignite to anthracite.

5 The criteria to be considered for classifying under these two general factors are proximate and ultimate analyses, calorific values, microscopic examination, extraction with solvents, reaction with reagents, and destructive distillation. (Report of Sectional Committee on Classification of Coal presented at the Annual Meeting of the *American Society for Testing Materials*, Atlantic City, N. J., June 24 to 28, 1929. Abstracted from advance publication 9 pp., *g*)

The Cohesite Process of Briquetting Lignite

THE Cohesite process plant is located at Bienfait, Sask., and is said to be entirely automatic, manufacturing the binder continuously from materials obtained locally and measuring out the finished binder in correct proportion to the flow of lignite coke.

The carbonizing plant is on the Lurgi system, which is generally known. The products from the retort can be classified as gas, tar oils, and coke. The nature of the tars depends on the temperature at which the process is operated, and it is a feature of the Lurgi retort that it may be operated as a low-, middle-, or even high-temperature process. The binder is apparently an asphalt brought by water, and if asphalt alone is used from 9 to 12 per cent of binder is required to get a briquet of suitable strength from lignite coke. The original article gives a diagram of the Lurgi carbonizing retort, and shows some of the details of the plant used in the Cohesite process. Cost figures for the Canadian plant are also given. (*The Iron and Coal Trades Review*, vol. 118, no. 3196, May 31, 1929, pp. 821–822 and 826, 4 figs., *d*)

INTERNAL-COMBUSTION ENGINEERING

The Rateau System of Diesel-Engine Supercharging

BURMEISTER AND WAIN are building a twin-screw vessel for the Blue Funnel Line which is said to be the highest-powered four-stroke single-acting machine (9600 b.hp.) yet constructed. The engines are of the airless-injection type and are equipped with superchargers built by the Rateau Company of Paris. These engines are eight-cylinder with a bore of 750 mm. (29.5 in.) and stroke of 1500 mm. (59 in.). The output is 3200 b.hp. at 105 r.p.m. without supercharging or 4800 b.hp. with supercharging, making the maximum output of the propelling machinery in each of the two vessels 9600 b.hp.

In order to obtain an idea of the principles employed in connection with the Paris trials, a brief note is required before passing to an examination of the full equipment. The supercharging blower discharges its air into a combustion tank in which oil fuel is burnt. The hot gas thereby produced is led to the turbine inlet, so that the tank in reality replaces the Diesel machinery. It is claimed that the greater regularity of the action involved permits very precise observation of the phenomena; the determination of the efficiencies may be made without measuring the capacity of the gas, as it is considered sufficient for the purpose to read the temperatures and pressures recorded.

Each set of superchargers—that is to say, a unit supplying half of one engine—comprises two blowers. As regards the shafting, the blowers are entirely independent, for although the exhaust-gas turbines revolve in the same casing, are mounted in alignment on the same bedplate, and the supercharging blowers have a common outlet, the shafts carrying each turbine and blower are separate. The turbines are of the single-stage impulse design.

In the trials conducted by the Rateau Company, air discharged from the blowers was taken through a pipe to a specially devised combustion chamber. Formerly, of course, the air would be led to the inlet pipe of the engine. In the combustion chamber the temperature of the air was raised to about 450 deg. cent, corresponding to that of the exhaust gas of the engine.

The trials of the first engine for the Blue Funnel Line were carried out in May of this year, and the installation of the machinery will be made shortly. (*The British Motorship*, vol. 10, no. 111, June, 1929, pp. 94–95, 2 figs., *e*)

The Packard Aero-Diesel Engine

THIS is the first time that more or less complete engineering data of the 9-cylinder 200-hp., air-cooled Packard Diesel engine have been made available.

The outstanding technical features of the Packard Diesel—which are organically related both to the essentials of Diesel practice and of aeronautic technology—appear to be the use of but a single valve for the admission of air and the discharge of exhaust gases, and the adoption of a practically 100 per cent constant-volume cycle. Firing pressures above 1000 lb. per sq. in. are allowed for in the design, while phenomenally low fuel consumption, low exhaust terminal pressures, and temperatures, and a reduction in weight per horsepower to a figure compatible with airplane requirements are attained.

Operation with air cooling and but a single valve seems to be the really radical departure from current Diesel practice, although the single valve has an apparent prototype in the Gnome "Monosoupape" (mono-valve) radial aviation gasoline motor and in an old patent specification of Dr. Diesel's. These features, taken together as the kernel of the Packard Diesel airplane design, appear outstandingly responsible for the engine's low weight of less than 3 lb. per hp., and for its consequent ability to propel an airplane. High firing pressures, contrary to the now obsolete viewpoint, do not increase specific engine weight, because they add to efficiency and power in greater proportion than to the extra metal sections required. Actually a net reduction in specific weight is attained.

The engine is said to have no exhaust pipe and no intake pipe, as well as no manifolds. The piston in one of the nine cylinders is connected to the crank by means of a master connecting rod whose crankpin end carries the eyes for linking up to the rods of the remaining eight pistons. Close to the base of each cylinder is mounted a cam-operated fuel-injection pump, with its injection tube leading up to the side-mounted spray valve and its suction line branching toward the circular fuel-supply header.

A diagram showing the operation of the single-valve Diesel aviation engine is given in Fig. 1. After the charge of air has entered the cylinder through a suitable opening, it is necessary, of course, that it be closed off at the moment when compression is to begin, this being readily capable of accomplishment by the mono-valve. As soon as the cylinder charge is ready to be exhausted, the same identical valve would again be opened, permitting the gases to escape into the powerful current of air thrust backward by the propeller. And the same valve can then remain open and at rest while the piston reverses at the dead center, being closed again only after the piston has drawn in the next charge of fresh air. An inspection of the diagram

reproduced herewith makes this process apparent to the eye, while the comparative representation of the conventional two-valve arrangement throws into clear relief the simplicity and general mechanical superiority of the mono-valve feature.

Increasing the piston speed with an engine of the Packard single-valve type is therefore not so likely to lead to difficulty as in two-valve machines of conventional construction, mainly for the reason that up to the rated piston speed the net weight

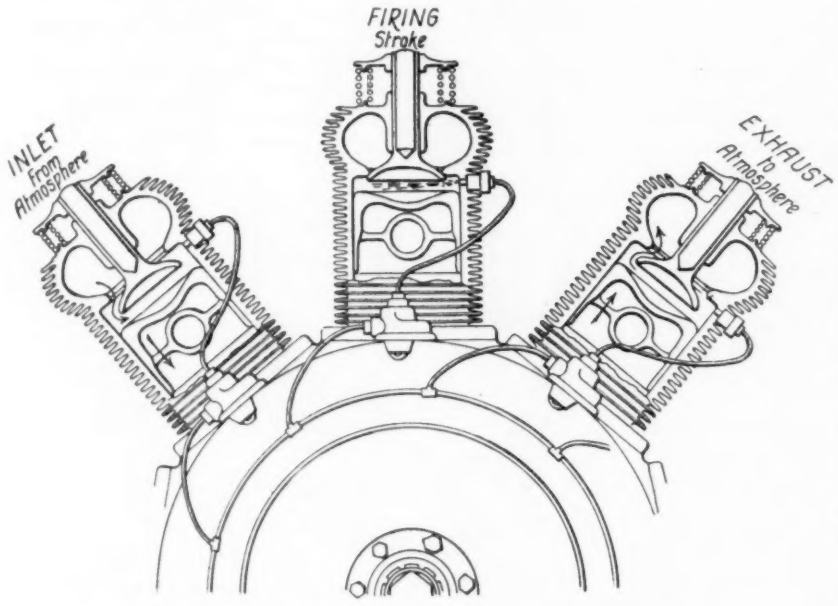


FIG. 1 DIAGRAM OF MONO-VALVE DIESEL AVIATION ENGINE

of oxygen entering the cylinder and effectively available for combustion does not diminish. Nor is it so likely that cam and valve acceleration limits will be reached so soon with the relatively easy timing of the single valve. But increases in piston speed, when legitimately made without sacrificing air supply, are a potent factor in increasing engine output, as is readily shown by the formula

$$\text{Hp.} = \frac{PV^3}{2330\,N^2r^2}$$

P being the mean effective pressure, in pounds per square inch, V the piston speed in feet per minute, N the r.p.m., and r the stroke-bore ratio. If N is fixed by considerations of propeller efficiency and r by structural requirements, it is obvious that engine rating per cylinder is dependent on the cube of the piston speed. In selecting a valve arrangement which permits high piston speeds the Packard engineers therefore seem to have taken a long step toward solving the problem of specific weight reduction in a Diesel engine. (*Oil Engine Power*, vol. 7, no. 6, June, 1929, pp. 328, 329, 330, *d*)

MACHINE PARTS

The DeLavaud Free-Wheel Differential

THIS design possesses the advantage that it is in the form of a compact self-contained unit that can be bolted on to the existing crown wheel or worm gear and takes then the place of the ordinary differential. It is said that in a car fitted with this device skidding is practically eliminated. The ability to coast at will is expected to reduce the wear and tear of the engine and transmission, besides providing a considerable saving in fuel.

The actual form taken by the gear to permit of its application in place of the ordinary differential gear is varied slightly to suit different makes of car, but the operating principle is the same in all cases and can be followed by reference to Fig. 2, which shows an arrangement of the gear as fitted in the rear axle of a Morris car. The crown wheel is indicated at *A*, the free-wheel differential gear being attached thereto by bolts *B*. The number and radial position of these is regulated to suit the holes used in attaching the ordinary differential gear which is displaced.

The body of the gear is machined internally with a series of cam faces and contains two separate clutches of the roller type. Each clutch consists of a center roller face *F-G*, Fig. 2, one of the clutches being coupled to the axle shaft *D* and the other to the corresponding shaft *E*. The rollers of both clutches, as seen at *H-J*, are accurately spaced by means of flanged bronze cages. These do not impede the movement of the rollers in either clutch, but they are coupled together in such a manner that they can turn slightly in relation to one another.

The connection consists of three steel balls loaded by springs recessed in one cage and pressed into dimples machined in the opposite cage, as seen at *K*. In addition to providing a certain amount of elasticity between the two cages the spring-loaded balls press the cages apart and cause them to make frictional contact with their inner flanges against the side faces of the respective roller races.

On each side of the body, cover plates *L-M* are provided. These are machined with ball races matching similar races on the

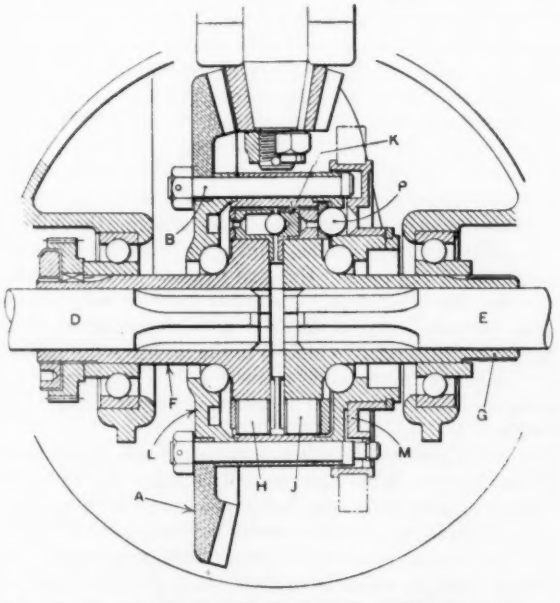


FIG. 2 SECTIONAL VIEW OF DELAVAUD FREE-WHEEL DIFFERENTIAL GEAR AS APPLIED TO A MORRIS CAR

shoulders of the roller races *F-G*, the radial bearings thus provided supporting the whole assembly. It may be noted that one of the cover plates *M* has an extended boss which is machined on the

periphery to carry a brake ring. Pegs on the plate project through slots in the ring, the angular relation between the two being set by a spring which pulls the end of one slot against the corresponding peg. Surrounding the ring is a spring-loaded brake band, a projection on this making contact with a stop fitted to the axle casing. The stop is operated from the dashboard of the car and its function is to control the free-wheel motion. Withdrawing the stop throws the free wheel out of action but does not effect the differential motion. This is in constant operation under both fixed and free-wheel conditions.

On turning the car, as in cornering, the outer wheel requires to turn faster than the inner wheel. This action is permitted due to the fact that the frictional drag of the roller race coupled to the faster-running wheel tends to advance the corresponding roller cage slightly in relation to the cage in the clutch of the slower-running wheel. As a result the clutch of the faster-running wheel becomes free. The motion operates in both forward and reverse directions, and its advantage when running over soft ground or surfaces tending to produce a skid is that the wheel that tends to slip becomes free, while the wheel that is gripping the road continues to drive and will hold the car straight or carry it forward until the other wheel gets a bite on the road, when this also commences to drive. The action is extremely sensitive and has been demonstrated as a preventative against skidding on ice-bound roads.

The differential motion as above described is directly opposite to that of an ordinary differential gear in which the wheel that slips tends to take the drive, thus accentuating and not minimizing the skid.

The remainder of the article gives interesting details as to the production of the gear. The part dealing with the roller race and roller cage are particularly interesting. (*Machinery* (London), vol. 34, no. 862, Apr. 18, 1929, pp. 65–71, 18 figs., *d*)

The Humfrey-Sandberg Reduction Gear

IN A PREVIOUS issue of MECHANICAL ENGINEERING (vol. 49, no. 9, Sept., 1927, pp. 1018–1019) the Humfrey-Sandberg unidirectional clutch was described in its application to motor cars. It has been now applied as a reduction gear for use in the chemical industries. The essential property of this mechanism is that it transmits torque in one direction only. This effect is obtained by transmitting the drive through cylindrical rollers interposed between races as in an ordinary roller bearing (see Fig. 3), with the difference that in the Humfrey-Sandberg device the axes of the rollers are inclined at an angle to the axes of the races, the paths of the races being of conoidal form, thus permitting the cylindrical rollers to maintain line contact throughout their length between the surfaces of the races. Relative motion between the races in one direction of rotation immediately jams the rollers between the race surfaces, and thus the drive is transmitted from one race to the other, while relative motion in the reverse sense allows the rollers to rotate in the same manner as in the ordinary roller bearing, and thus no drive is transmitted between one race and the other.

The unit is mounted on the driven shaft to which is connected a link motion (Fig. 4) arranged in such a manner that the amount of oscillation imparted to the clutch unit from a drive running at a constant speed can be varied at will between specified limits.

The link motion employed is very simple, and consists of an operating lever *A*, which is oscillated at a constant speed by a suitable crank and connecting rod or similar reciprocating motion from the driving member or prime mover, as the case may be. In the operating lever *A* provision is made for varying the position of the pin and roller *B*, which engage in a slot *C* attached to the driving member of the clutch *D*, so as to vary the radius at which this pin and roller *B* operate with reference to both the fulcrum pin *E* of the oscillating lever and the center *O* about which the clutch unit *D* is caused to oscillate.

It will be seen that as the position of the pin and roller *B* is varied in the above respect, the amount of motion transmitted to the clutch unit *D* is also varied in a multiplied form. Thus, the effect is that when the pin and roller are in the extreme posi-

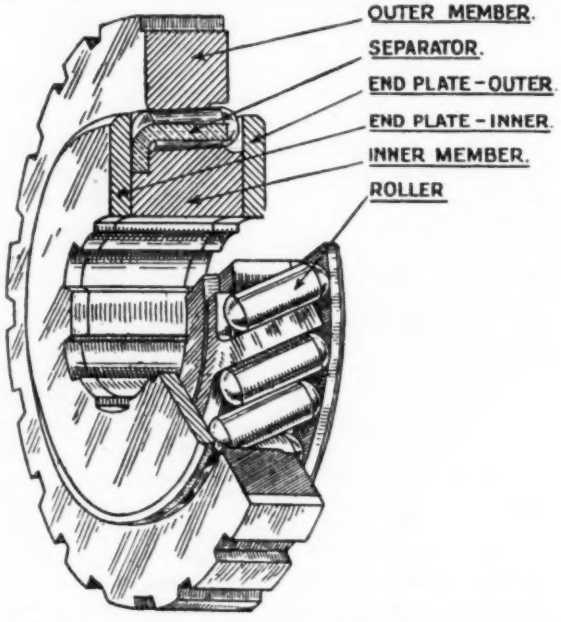


FIG. 3 THE HUMFREY-SANDBERG UNIDIRECTIONAL CLUTCH

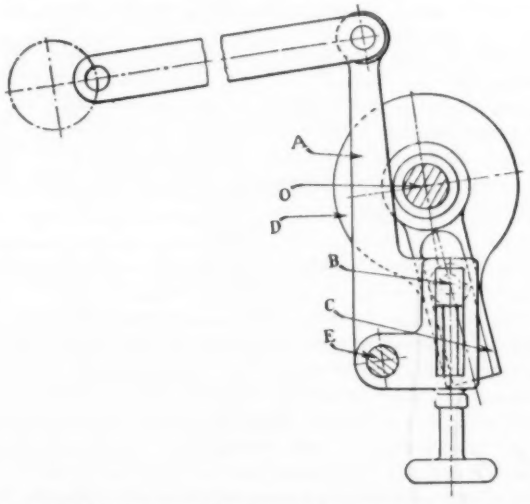


FIG. 4 LINK MOTION IN THE HUMFREY-SANDBERG UNIDIRECTIONAL CLUTCH

tion, in which they are at the greatest radius from the fulcrum pin *E*, and at the nearest approach to the center of oscillation *O* of the clutch unit, the greatest degree of oscillation is imparted to the driving member of the clutch. When at the opposite end of the slot on the driving member, the radius from the center *O* about which the clutch unit oscillates being at its greatest, the amount of oscillation movement imparted to the driving member of the clutch unit is at this point at a minimum, and in fact may be reduced to no motion at all. The movement of the pin and roller to any point between the above two limits will give any desired reduction ratio between the limits specified with absolutely

positive operation. (*The Industrial Chemist*, vol. 5, no. 52, May, 1929, pp. 197–198, 3 figs., *d*)

The Tubular Rivet

IN ITS elementary form this rivet consists of a short length of mild steel or wrought-iron tube, sawn or ripped to appropriate length, with the ends left square and free from rag. These blanks are heated at one end and inserted, cold end down, into the die of a quick-acting power-driven press, so that the descending ram, which bears a conical-pointed punch, forms or expands a countersink at one end of the tube.

The rivet (shown at 1, Fig. 5) is then ejected, reheated, and annealed to secure ductility and softness.

When used for coupling up lengths of conveyor chain that run in somewhat inaccessible positions, the rivet is inserted through

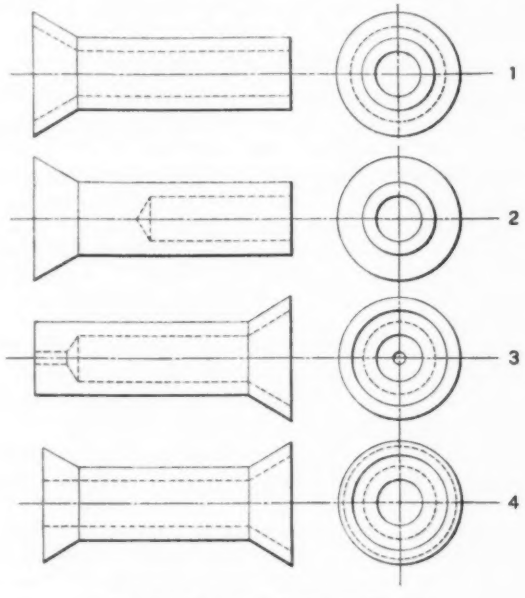


FIG. 5 FORMS OF TUBULAR RIVETS

the links, a heavy and preferably conical-pointed "dolly" is held up to the countersink end, and a few blows with hand hammer and center punch will form a countersunk rivet head at the opposite end. This work is of course performed cold, and can be carried out more easily and more quickly than if the normal solid rivet were used; and by suitably proportioning the countersink of the links the rivet head can be made either flush with or below the face of the link as desired.

A modified form of tubular rivet consists of a normal, solid countersunk rivet, which, after annealing, is placed in the collet of a small turret lathe and drilled up for part of its length, as shown at 2 in Fig. 5.

By expanding the drilled end after the rivet is inserted in position, all the advantages of a true tubular rivet can be secured, but at a lessened cost.

A third variety of tubular rivet, for use in positions where it is only possible to get to one side of the job, is shown at 3. A short length of rivet bar is chucked and drilled right through and the bore then opened out for part of its length to a larger diameter. This end is then heated, and a countersunk head formed in a power-driven press.

In use the rivet is inserted in position, and a parallel drift, of suitable diameter, is driven right through. In penetrating the smaller hole, the drift forms a swelling at that end of the rivet, resulting in a fair rivet head, as at 4. This operation can be carried out either hot or cold, depending upon the material used and the purpose for which the rivet is designed. Care must be taken, and experiments made, to insure that a rivet of suitable proportions is used. Otherwise an unreliable fastening may result. [E. J. in *Machinery* (London), vol. 34, no. 867, May 23, 1929, pp. 245, 1 fig., *d*]

MACHINE-SHOP PRACTICE

The Function of Milling Machines and Cutters in the Removal of Metal

THE author questions whether or not the standardization of milling machines has been successful. He asks whether or not it is advisable to abandon the matter of economy of manufacture and purchase price of automatic milling equipment in favor of higher productivity. It appears that production is proceeding at such a rapid pace and such great demands are made for high production from machine tools that the machine tool and the cutting tool must be designed as specifically as possible for the particular job in mind. A slight difference in specification of the material to be worked on may have a great deal to do with the design of the cutting tool. Likewise the structural design on which the milling cutter is to work will also have considerable bearing on the design of the cutter. For that reason there is some tendency among the manufacturers to meet the special requirements of a particular user rather than to adhere to any specific standard, and it is believed that this is not only the more correct but the more economical way.

There is another point to which attention should be called, and that is the fact that on certain types of milling machines it has generally been the practice to feed the work into the cutters, i.e., the cutter being maintained in a fixed position while the work is fed to it, either up or under. Undoubtedly there are many points in favor of this, but the question is whether or not it was originally started as an expedient and maybe as a first thought, rather than as the result of comparative tryout.

On the other hand, a cutter rigidly supported on an arbor and with proper spindle bearings and properly mounted can be fed into the work by holding the latter in a fixed position, the cutter being allowed to sink in to a certain depth or to proceed in a horizontal or vertical travel, or in a combination of the two. This has several advantages. By cam-actuated motions it can readily be seen that it is possible to get an intermittent motion or travel, and by so doing it is possible to slow up the feed if a thick or heavy cut is encountered, or to speed up to accelerate the travel of the cutter if a light cut is encountered, such as would be the case when milling through sections of different thicknesses, widths, or depths of cut, or different types of material. With a positive screw and gear feed this is not possible. For example, suppose it were necessary to mill through a laminated section of tool steel and cast iron. Naturally, the cutter can proceed through the cast-iron section much more rapidly than through alloy steel. This can be accomplished on the type of machine illustrated in the article because of its cam-actuated feeds in which a cam throws a clutch into different speeds. (N. M. Marsilius, President of the Producto Machine Co., Bridgeport, Conn., and F. A. Westbrock in *Western Machinery World*, vol. 20, no. 4, Apr., 1929, pp. 135–136, illustrated, *d*)

MACHINE TOOLS

The Hutto Naval-Gun Grinding Machine

THIS machine was developed by the Hutto Engineering Company, Bush House, W.C. 2, London (probably the British branch of the American company of the same name), for grinding naval guns by the honing method.

The machine is mounted on skids, the forward end being secured to the muzzle of the gun barrel by means of a large split clamp. After mounting the machine on the gun it is only necessary to support the rear ends of the skids with blocks or jacks, so that setting-up time is reduced to a minimum. Eyebolts are provided on the machine so that it may be readily transported to the work. Mounted on the skids are two brackets which accommodate the guide rods and a coarse-pitch traversing screw for the driving-motor head. The main driving motor develops $7\frac{1}{2}$ hp., and drives the grinding head through a series of adapters and universal joints at a speed of 60 r.p.m. The reciprocating motion is derived from a 3-hp. reversing motor mounted at the end of the machine and driving the traversing screw through reduction gearing. The stroke of the machine is 5 ft. and the traversing speed 45 ft. per min.

The grinding head carries two sets of stones, the length over the stones from end to end being 30 in. During the grinding operation a copious flow of kerosene is supplied through a flexible pipe to a spray wheel integral with the grinding head. The muzzle end of the gun is elevated to an angle of approximately 6 deg., so that the kerosene runs back to a tank at the breech end.

The length of the ground bore of the barrel shown in an illustration in the original article is approximately 48 ft. A thickness of 0.015 in. of stock comprising corroded copper and steel was removed and the bore finished to within a limit of 0.001 in. in $8\frac{1}{2}$ hr. actual machining time. The machine is supplied complete with grinding heads for 12-, 14-, and 16-in. bores, and with suitable adapters for the various diameters. [*Machinery* (London), vol. 34, no. 867, May 23, 1929, pp. 244–245, 1 fig., *d*]

MARINE ENGINEERING (See also Internal-Combustion Engineering: The Rateau System of Diesel-Engine Supercharging)

METALLURGY

A New Method for the Production of Sound Steel Ingots

THE authors' method of overcoming segregation and axial unsoundness is based on the principle that the freezing of the ingot should proceed from the bottom upward, the isothermals being substantially parallel to the bottom of the ingot.

A British patent, No. 278,032, was granted to the authors for a process of casting steel ingots comprising the pouring of the molten metal into a mold having its longitudinal dimensions greater than its vertical; thick refractory materials covering the sides of the mold and a bottom chill of large dimensions, preferably of metal; preheating the mold to a high temperature of the order of that of molten steel before pouring the metal therein; and continuously supplying heat to the upper surface of the molten metal after casting, so that the upper layer is the last to solidify.

The mold consists of a strong sheet-steel casing, slightly conical in form and reinforced by heavy angles at the top and bottom. The casing is lined with shaped firebrick quarls closely fitted together and to the outer casing, and is preferably provided with lifting eyes riveted to the sides.

The cover is likewise made of suitably shaped firebrick quarls fitted together and into a massive steel angle ring, which retains them. The cover may be lifted by the eyes riveted to the ring.

In the cover one or more suitable holes are provided for the insertion of gas or oil burners, and also one or more suitable vent holes to allow the hot gases to escape. The burners are used for applying heat to the surface of the metal after pouring, in order to keep the top layer molten until the last, while the mold is preheated by setting it, with its cover in place, on the top of the adjoining firebrick table containing suitable gas or oil burners delivering flame upward. If desired, the burners may be used for preheating the mold. The cover is also provided with a hole for use when pouring.

The chill block may be of cast iron or steel, formed of one or more pieces fitted together; it is perfectly protected on its upper surface against the wash of the molten steel by a thin steel plate which is easily renewable.

A circular ingot, height 45 in., diameter 70 in., and weight $20\frac{1}{2}$ tons, was cast by the new method. It showed no trace of V-segregate or axial weakness, and the main segregate was only noticeable at the top, which would be discarded. Attention is drawn in the paper to the uniformity and to the absence of serious segregation. [Hon. Sir Chas. A. Parsons (Hon. Mem. A.S.M.E.) and H. M. Duncan in a paper before the British Iron and Steel Institute; abstracted through *The Iron and Steel Industry*, vol. 2, no. 8, May, 1929, p. 248, *d*]

Dangerous Heat Treatments

THE author points out a number of instances where incorrect heat treatment results in a weakened material. In mild steel, for example, improper heat treatment is apt to lead to low impact strength due to the formation of carbonless bands in the material and the promotion of coarse ferrite crystals.

In the case of high-speed steel it is often assumed that it is only necessary to preheat, harden, and temper at temperatures approximately correct to obtain good results. Exposure time and temperature are all-important, and neglect will be dangerous to good work.

Preheating is often carried out in a most haphazard way, any temperature between 700 and 950 deg. cent. being chosen, and the tool allowed to soak for long periods. Such treatment, even if allowed by correct hardening, may cause brittleness.

Insufficient forging and working at too low a temperature are also dangerous where high-speed steels are concerned. Forging at an excessively low temperature will produce cracks.

Case-hardening is one of the commonest operations carried out in heat treatment, and for this reason probably receives scant attention. Here, as in all other thermal treatments, time and temperature must be looked after. Troubles which arise are mainly due to three causes: (1) Selection of an inferior case-hardening compound; (2) fluctuation of carbonizing temperature; and (3) incorrect refining and hardening.

The use of a good compound is essential, otherwise poor penetration, flaking of case, or formation of two layers of different carbon content will result. One giving an even penetration and containing a minimum of hydrocarbons is most suitable.

Carbonizing temperatures must be kept even; oscillation of temperature will cause the concentration of cementite in zones, with grave danger of the case's flaking off in service.

Frequently the refining operation is missed altogether, or is partially attempted by quenching the articles from the carbonizing heat without allowing the box to cool down, and then reheating the parts. A little consideration of the severe treatment to which articles are subjected at the casing heat will show how necessary it is to refine the core. By carefully reheating to 920 deg. cent., and quenching in oil or water, the coarse structure developed in the core of a mild steel will be refined to a fine fiber. This treatment, followed by reheating to 780 deg. cent. and quenching in water, will produce a hard-cased article of fair strength. Properly treated, such a steel will give in the core a tensile strength of approximately 38 tons per sq. in., and an Izod figure of 42 ft-lb. Case-hardening steels of the nickel varieties are liable to the same troubles, but to a lesser extent, if exposed to treatment entailing the defects mentioned.

As an instance where neglect of the time element in heat

treatment may cause dangerous failure in components, the following case is interesting.

The compounds in question were gun recoil springs, which had to withstand severe shock. After forging they were annealed in charcoal prior to machining. Following machining, forming was carried out in the hot state. A refining operation, consisting of quenching in boiling water, with a subsequent anneal, was performed after bending. The springs were then carefully fitted to size, adjusted to profile, hardened, and tempered. In service an unusual amount of breakages occurred, and upon investigation it was found that the length of time the springs had been exposed to the various temperatures had produced a divorce of the pearlite.

To overcome this trouble annealing operations were replaced by normalizing. Heating for the normalizing, refining, and hardening operations was carried out in a lead pot, the exposure time being reduced to a minimum, and no further failures from this cause resulted. (*Canadian Machinery and Manufacturing News*, vol. 40, no. 9, May 2, 1929, pp. 47–48, *p*)

POWER-PLANT ENGINEERING

Powdered-Fuel Firing by Pregasification

DESCRIPTION of the "H & M" powdered-fuel burner recently tested on a Lancashire boiler at Grimethrope colliery. It is believed that the high angle and velocity at which dispersive-type boilers distribute the fuel cause a great deal of the coarser coal and most of the ash to be thrown out of the flame by centrifugal force on all sides.

One way to reduce the length of the flame from a given mixture of air and powdered coal is obviously to reduce the velocity of the fuel and air as it enters the combustion chamber so that the same time for combustion is obtained in a shorter distance. But if firing back inside the burner is to be avoided the velocity cannot be reduced below a figure that is in excess of the rate of flame propagation of the mixture. Experiments were made in this direction, and it was found that different proportions of powdered fuel and air have different rates of flame propagation. In the ordinary powdered-fuel burner the ratio of the mixture of coal and air was found to be generally between 5 and 10 lb. of air per pound of fuel. Further investigations showed, however, that coal and air mixtures as "rich" in coal as 1 lb. per 3 lb. (or even less) of air had rates of flame propagation in the neighborhood of half that of the usual 5:1 mixtures mentioned above, and they also showed the interesting fact that coal and air mixtures as "weak" in coal as 12 lb. (or more) of air per pound of coal had rates of flame propagation also in the neighborhood of half that of the usual mixtures.

In the "H & M" burner these phenomena are employed to advantage. Inside the body of the burner a separating action takes place which produces two distinct mixtures of the coal and air which have different coal densities. In other words, one of the mixtures is very "rich" and the other very "weak." It should be said that the mixture originally supplied to the burner is a mixture in which the air may be from three-quarters to the whole amount required for the combustion of the fuel contained in it. In passing through the burner, the original mixture is automatically separated into two mixtures, each of which is passed to a separate annular orifice. The two streams are concentric, and converge and mix immediately upon their exit from the burner. When these two streams mix there is formed, naturally, one mixture having a coal density exactly equal to that which was originally supplied to the burner, but the important feature obtained by introducing fuel in streams of different density is that they may be allowed to issue from the orifices at quite low velocity—that is, at about half the velocity necessary in the usual powdered-fuel burner. This low velocity is possible by virtue of the fact that each of the two streams has an air-to-coal ratio giving the low rate of flame propagation referred to above. Thus, in spite of the low exit velocities, there is no possibility of firing back into the burner.

The result is that the forward-moving velocity of the fuel cloud formed by the mixture of the two steams is comparatively low, and the distance through which the fuel particles have to travel before they are completely burnt is consequently very much reduced, although the time in which they have to burn is the same as, or greater than, would be with a higher speed and longer travel. The flame produced from this combination of streams is not a wide-angle flame, although it is a very short one due to its comparatively low speed.

Owing to the specially proportioned mixtures, it is claimed that the flame fires back exactly to the point where the two streams mix, and no farther. This was clearly observable in a demonstration burner erected in a disused brick kiln at Grimethorpe colliery, where the commencement of the flame was seen to form a definite line about 4 in. in advance of the burner orifices.

The test results are given in the form of a table in the original article. The total unburned carbon formed only 1.59 per cent of the coal fired. (*The Power Engineer*, vol. 24, no. 278, May, 1929, pp. 198–200, 2 figs., *de*)

60,000-Kw. Steam Turbine for Lakeside Station

THE Lakeside unit is single-cylinder one running at 1800 r.p.m., whereas the unit built eleven years ago was a cross-compound one with three cylinders—one high-pressure and two low-pressure—a generator being connected to each cylinder. The running speed of the high-pressure turbine was 1800 r.p.m. The low-pressure turbines operated at 1200 r.p.m. to keep down the stresses in the low-pressure blades. The tip speed of the last spindle rows was only 608 ft. per sec. as against 1147 ft. per sec. for the newer machine. The total weight of the three-cylinder unit was 2,360,000 lb., while the weight of the new single-cylinder unit is 1,060,000 lb., or 45 per cent of the old unit. The floor space taken by the new unit is only a little more than that occupied by the high-pressure unit of the three-cylinder machine.

An important feature in the design of this turbine is the elimination of separate blade and dummy rings in the high-pressure cylinder. The general practice has been to carry the stationary blades and dummy strips in separate rings, supported in an outer cylinder. This design facilitated the machining of the grooves and the installation of the blading. For the larger sizes of cylinders, however, the saving in weight and cost due to the use of integral blade and dummy rings is found to offset the slightly more difficult machining. Two nozzle chambers are provided in the high-pressure end of the turbine, one in the base and the other in the cover. At the maximum load, steam is admitted directly into the impulse chamber, thus bypassing the impulse element. In order to withstand the high pressure thus obtained in the impulse chamber, 4-in.-diameter bolts are used in the horizontal flange around the impulse chamber. These bolts are heated by an electric heating element before tightening, after which the stress in each bolt is checked by measuring the stretch of the bolt with a micrometer.

An important improvement in the spindle design is obtained by moving the spindle joint from the high-pressure end to the lower-pressure section where the temperature variation is small. Due to this changed location it was also possible to make the part of the spindle that carried the heavy low-pressure blading of a 3.5 per cent nickel-steel forging. This material can be

stressed 15 per cent more than the ordinary 0.40 per cent carbon steel used in the remainder of the spindle, thus shortening the turbine by several inches. The nickel-steel forging is normalized and air-quenched and goes through the same heat treatment as an ordinary carbon-steel forging.

A simple instrument in the form of a spindle truth indicator has been developed for the purpose of measuring the amount that the spindle is out of true. When the spindle is rolled slowly, the radial movement of the spindle at a point outside of each spindle gland can be read in thousandths of an inch on a dial. With this knowledge the operator can tell if the spindle is heated uniformly enough to allow the turbine to go on the line. When the turbine is shut down the spindle will have a tendency to distort, due to temperature differences. In this turbine, provision has been made for three different methods of preventing such distortion. The first method consists in providing air nozzles through which air may be blown into the cylinder cover. This insures that the mixture of air and steam will keep circulating around the spindle and maintain a substantially uniform temperature throughout the cylinder. The turbine is also equipped with a motor-driven spindle-turning gear that will keep the spindle revolving at approximately 25 r.p.m. to insure uniform cooling during the shutdown period. The third alternative consists of turning the spindle 180 deg. when it is bent upward the maximum amount that is considered permissible when starting the turbine. The spindle will then be bent downward and will first straighten out and then bend upward again. Then the spindle is revolved another half a turn. The barring of the spindle is accomplished by means of an oil-operated jacking gear supplied with oil at 400 lb. pressure. During the barring operation, oil is pumped to the turbine and generator bearings to create an oil film between the journal and the bearing shell. The last method has the advantage of requiring the smallest amount of power.

A new side-entry type of fastening is adopted for the last three rows of spindle blading. The root of the blade is machined on a short arc of a circle that conforms with the curvature of the lower blade body. The section of the root is serrated. The blades are thus fastened to the spindle over the entire width of the blade. The curved shape of the root and the blade body offer a high resistance against vibration about the axis of the minimum moment of inertia.

The throttle valve is of a new, oil-operated type. High-pressure oil is admitted below the operating piston and is balanced by springs above the piston. The handwheel stem operates a pilot valve in the center of the piston. Opening of the valve is accomplished by high-pressure oil when the handwheel stem is raised. Only a small effort is therefore required by the operator for opening the valve. The automatic trip mechanism releases the pressure of the oil in case of overspeeding, thus tripping the throttle valve. It is therefore evident that the throttle valve can be opened only when the oil pressure in the system is established so that proper lubrication of the bearings is secured when starting. If for any reason the oil pressure should drop below a predetermined value, the valve will trip and automatically shut down the turbine.

Care was taken in the design to obtain a pleasing appearance. The oil piping is, for example, carried around the unit in a trench, covered with floor plates. The oil tank and auxiliary oil pumps are located below the floor. The turbine lagging is smooth, with well-rounded corners. All steam piping is in the basement. This is illustrated by Fig. 6. (H. V. Rasmussen, Large Turbine Engineering Dept., South Phila. Works, Westinghouse Electric & Mfg. Co. in the *Electric Journal*, vol. 26, no. 6, June, 1929, pp. 264, 265, 266, 267, 268, illustrated, *d*)

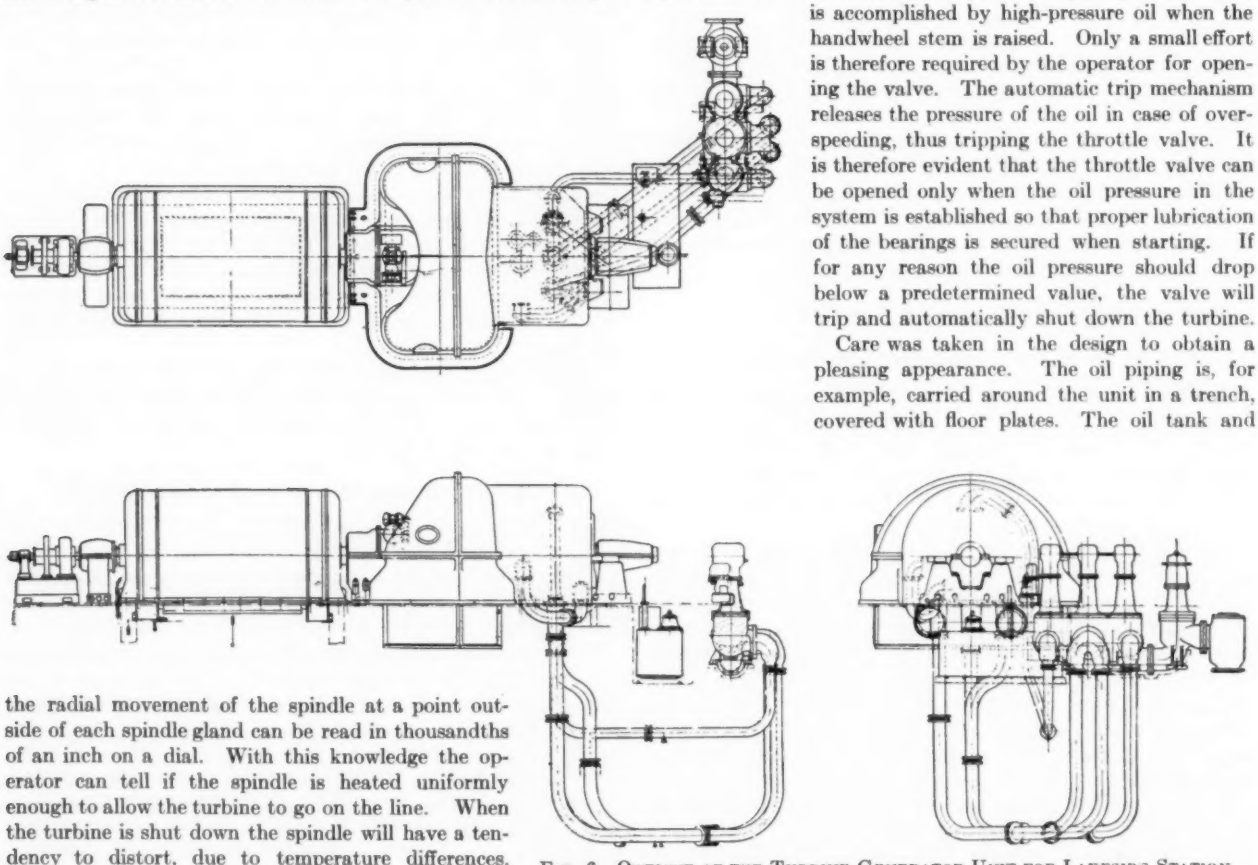


FIG. 6 OUTLINE OF THE TURBINE-GENERATOR UNIT FOR LAKESIDE STATION

The Burg Pulverized-Coal Equipment for Flame-Tube Boilers

THERE are at present 4719 boilers under the supervision of the Association for Supervising Power Economy in the Ruhr Collieries. Of these, 2700 boilers, or 58 per cent of the total number, are flame-tube boilers, mostly with flat grates, and, in a few cases, with gas or waste-heat firing. Only 104 boilers have pulverized-coal burners, and only 30 of these are flame-tube boilers. The author suggests that the reason why so few internally fired boilers employ pulverized coal is to be found in the faulty design of the equipment hitherto employed. In the past it has been necessary to use a combustion chamber of $8^1/_2$–$9^1/_2$ cu. m. (cubic meters) for an internally fired boiler of 100–110 sq. m. heating surface, in order to obtain an evaporation of 20 kg. per sq. m. This required considerable space in front of the boiler and in the ash basement. The loading of the com-

bustion chamber was only about 180,000–200,000 kg-cal. per cu. m. per hour, and radiation from the flame to the heating surface was small, only the two flue openings of 850–950 mm. diameter being available. The firebrick ring needed to protect the front riveted joint of the flue had a constricting effect, and the life of the combustion chamber seldom exceeded one year. Particulars are given of the construction and tests of a Burg pulverized-coal burner applied to a corrugated-flue boiler of 103 sq. m. heating surface. The furnace consists of a cylindrical chamber about 3 m. in overall length and 1 m. in greatest internal diameter. The coal and air mixture is introduced through spiral plates which set up vigorous eddying, and the secondary air is preheated in a casing round the chamber and introduced tangentially through "nozzles" in firebrick rings. The coal-carrying air is preheated to 100 deg. cent. in a casing around the combustion chamber. A water-cooled ring of 4.1 sq. m. heating surface protects the front riveted joint. Fused ash runs into the ash basement through a comparatively narrow slot. Steam jets under the water-cooled guard ring keep the front of the flue free from ash. The following is an abridgment of the test data obtained from the experimental boiler: (*a*) with the Burg burner fitted to an existing Orange combustion chamber; and (*b*) with the combustion chamber lined to cylindrical form.

	(*a*)		(*b*)	
Lower calorific value of fuel, kg-cal. per kg.	6593		6629	
Higher calorific value of fuel, kg-cal. per kg.	6853		6892	
Weight of fuel burnt, kg. per cu. m. of combustion chamber per hr.	75.4		113.7	
Evaporation, kg. per sq. m. heating surface per hr.	38.3		31.74	
Feed inlet temperature, deg. cent.	64		51.2	
Steam pressure (saturated), atmospheres gage.	7.1		7.2	
Kg-cal. per cu. m. combustion chamber per hr., referred to lower calorific value	497,508		753,727	
Flue gas at end of boiler:				
CO_2 per cent	13.3		13.4	
O_2 per cent	5.8		5.9	
CO per cent	0.1		nil.	
Temperature in combustion chamber, deg. cent.	1352		1178–1280	
Temperature at end of flue, deg. cent.	813		717	
Temperature at end of boiler, deg. cent.	547		478	
Temperature of primary air, deg. cent.	260		126	
Temperature of secondary air, deg. cent.	24		15	
Evaporation (including cooling ring), kg. per kg. of coal	7.07		7.78	
Heat balance, referred to lower calorific value:				
In steam, per cent	51.52		58.95	
In cooling ring, per cent	12.47	63.99	12.83	71.78
Chimney loss, per cent	27.97		24.52	
Unburnt gases, per cent	0.46		nil.	
Conduction, radiation, etc., per cent	7.58		3.70	
	100.00		100.00	

These tests were made without first cleaning the boiler. In test (*a*) the furnace and boiler were somewhat overloaded. It should be noted that neither a superheater nor an economizer was employed. In both tests a certain amount of trouble was caused by clogging of coal due to dampness. The coal dust was used without grinding, and left 32 per cent residue on a screen of 4900 meshes per sq. cm. The author suggests that the nozzles for the secondary air might better be made of heat-resisting cast iron. Better results could be obtained in a regular commercial installation using dry fuel and superheaters and economizers. Provision should be made for the mechanical removal of fly ash from the flue. (M. Schimpf, in *Glückauf*, March 2, 1929; p. 295, abstracted through *Engineering and Boilerhouse Review*, vol. 42, no. 12, June, 1929, pp. 672 and 674, *d*)

REFRIGERATION

The Guarini Ejector System

THERE have been many attempts to apply the ejector principle to produce refrigeration, particularly by Rey, Prache, and Bouillon. The Guarini system aims at using the heat directly to produce a propelling vapor of a refrigerating liquid more or less volatile and to use this vapor in an ejector (thermocompressor) producing a vacuum, and compressing the mixture of the propelling vapor and the aspirated vapor in a condenser where the vapor returns to the liquid state, part of this liquid being vaporized in the evaporator while the remainder, corresponding to the propelling vapor, returns to the boiler by using mechanical means.

A refrigerating cycle with compression is obtained in this way; the suction and compression in the cycle are obtained by a simple thermal effect by means of the ejector or thermocompressor, three types of which are illustrated herewith.

In Fig. 7, 2 is the ejector fed with the vapor from the boiler 7, filled with the refrigerating liquid—for instance, liquid ammonia

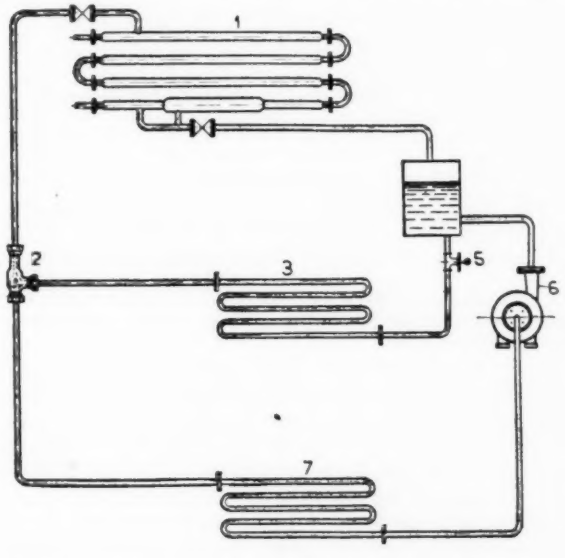


FIG. 7 SCHEMATIC DIAGRAM OF THE GUARINI EJECTOR REFRIGERATING SYSTEM

gas; 1 is a surface condenser, of which 4 is the receiver for the liquid; 5 is the valve regulating the quantity of liquid ammonia sent into the evaporator 3; and 6 is a pump which sends the excess of condensed liquid, that is, the liquid corresponding to the propelling vapor, back to the boiler 7.

The way the apparatus works is as follows: On heating the boiler 7, the vapor thus formed passes through the ejector 2 and produces a vacuum in the evaporator 3 by the exhaustion of the vapor produced in it. This aspirated vapor mixed with the propelling vapor condenses itself in the condenser 1. The condenser liquid is collected in the liquid container 4, from which a part is sent to the evaporator 3 by means of a regulating valve 5, while the remainder (corresponding to the propelling vapor) is sent to the boiler 7 by means of a pump 6.

In a modification of the above apparatus a venturi tube takes the place of the pump or injector. It does not appear that the apparatus is in commercial use as yet. (*Cold Storage*, vol. 32, no. 374, May 16, 1929, pp. 156–157, 4 figs., *d*)

CLASSIFICATION OF ARTICLES

Articles appearing in the Survey are classified as *c* comparative; *d* descriptive; *e* experimental; *g* general; *h* historical; *m* mathematical; *p* practical; *s* statistical; *t* theoretical. Articles of especial merit are rated *A* by the reviewer. Opinions expressed are those of the reviewer, not of the Society.

Engineering and Industrial Standardization

Résumé of Development of International Co-operation in Standardization Work to May 1, 1929

IN APRIL, 1926, a conference of representatives of 18 national standardizing bodies, held in New York, drafted the constitution of a general international organization for cooperation in matters of industrial and engineering standardization, to be called the "International Standards Association" (I.S.A.).

The aims and objects of the new body were ultimately formulated as follows:

a To lay the groundwork for international agreement upon standards by providing simple, systematic means of interchanging information on the standardization work and activities in the different countries.

b To develop general guiding principles for the assistance of the national standardizing bodies.

c To promote uniformity among the standards of the various national bodies.

d To cooperate with any international body engaged in standardization.

e The administrative machinery herein set up is so designed that it may be readily extended or modified to include the international approval of standards.

Item (*e*) implied that the establishment of international standards was *not* considered to be a function of the new body at the present time, but that it might become one of its functions in the future. For the time being, international exchange of information was to be its main purpose, carried out, however, in a more systematic manner than formerly.

An international committee of seven (representatives of the Belgian, British, Czechoslovakian, German, Swedish, Swiss, and American bodies) was appointed to confer with the International Electrotechnical Commission (I.E.C.) in regard to bringing about a unified organization, before submission of the new plan to the national bodies for final ratification.

First Meeting of Committee of Seven

The Committee of Seven met in London in September, 1926, with the Committee of Action of the I.E.C. It was not found possible to reach complete agreement, and on request of the American delegate, the establishment of the I.S.A. was postponed for one year, temporary arrangements, however, being made for continuing the international cooperation through a temporary central office located in London, and financially supported by the national bodies.

Second Meeting of Committee of Seven

A second meeting of the Committee of Seven was held in London in November, 1927 (not attended by the American representative), where the following recommendations were unanimously agreed upon for submission to the national bodies:

1 That the International Standards Association be established immediately, provided the funds necessary, in accordance with the schedule of contributions already circulated with the statutes, be forthcoming for the period of the three years: 1928, 1929, and 1930.

2 That the foundation of the International Standards Association date from the New York conference, April, 1926, and be in accordance with the statutes and by-laws, already circulated.

3 That it be established in a completely independent position, the central office being, for the present, in London.

4 That the Committee of Seven act as first council under the constitution.

5 That Sir Richard Glazebrook be elected the first president of the International Standards Association, discharging for the present the duties of general secretary, the appointment of the latter being a question to be dealt with by a plenary assembly.

The responses to the request for formal organization of the I.S.A. were favorable on the part of the majority of the national standardizing bodies. However, the British body unexpectedly declined to participate, and suspended the temporary international secretariat in London on March 31, 1928.

The German and Swiss national bodies then proposed, in order to prevent stagnation in the work, that Mr. Huber-Ruf continue to function as technical secretary in a central office, now to be located in Zürich, Switzerland. This proposal was supported by a large majority of the national bodies and put into effect.

Third Meeting of Committee of Seven

The third meeting of the Committee of Seven was held in Prague, Czechoslovakia, in October, 1928 (the American and British members not attending). Affirmative replies to the recommendations mentioned above, regarding the immediate establishment of the I.S.A., had been received from the following 16 countries: Austria, Belgium, Czechoslovakia, Denmark, Finland, France, Germany, Holland, Hungary, Italy, Japan, Norway, Poland, Russia, Sweden, and Switzerland.

The I.S.A. was therefore considered as having been regularly established in a tentative manner, the Committee of Seven being its first council. It was decided to submit the election of Professor Hoenig (the Swiss national chairman) to the presidency of the I.S.A., to a vote of the national bodies, as also a contract with Mr. Huber-Ruf to function as secretary for a further period of three years. Both items have since been ratified by the 16 national bodies mentioned above.

The vacant seats of the American and British bodies in the Council were offered to the French and Dutch bodies, while the wish was expressed that the A.S.A., and also the British body, might see their way clear to join the I.S.A. at a later date.

More than 20 projects, some of which had already been taken up, were considered as calling urgently for being dealt with in an international way, the secretariats for these projects to be taken care of either by one of the member bodies or by the central office. With regard to the projects, "Shaft Heights" and "Shaft Extensions of Electric Machinery," the central office was directed to proceed in cooperation with the I.E.C.

I.S.A.—I.E.C. Relation in General

With regard to the cooperation between the I.E.C. and the I.S.A. in international standardization work in general, no formal principles concerning a subdivision of the work have been laid down. As already indicated, the two international offices are cooperating in the case of certain "border-line" subjects. In no European country has any serious difficulty been experienced in coordinating the work between the national standardizing body and the national committee of the I.E.C. In several countries, such as Germany, Great Britain, and Holland, the national committee of the I.E.C. is essentially the same, and in some cases identical with the group dealing with standardization in the electrical field under the auspices of the national standardizing body.

Present Position of the A.S.A.

Although not yet having decided on the question of joining

the I.S.A., the A.E.S.C. financially supported the temporary central office in London by contributing the sum of $1125, for the period October 1, 1926, to September 30, 1927. A like amount was voted in principle for the next period of one year, but the finances of the A.E.S.C. have not yet permitted the payment of this contribution. Conditions have now been changed somewhat by the transference of the central office, the expenses in Zürich being assumed to be only 80 per cent of those in London (it would require, on the part of the A.S.A., the amount of $1186 to clear its obligations up to September 30, 1928, if it wished to be considered as having taken part in, and financially supported to the full extent, the international work until that date).

Although no financial support from the A.S.A. has been forthcoming for the period after Sept. 30, 1927, the central office in Zürich has regularly kept the A.S.A. fully informed about work under development, repeatedly expressing the hope that the A.S.A. would join in the near future and give further financial support.

In reply, the A.S.A. has stated that with a view to its reorganization and the appointment of a board of directors, whose prerogatives would include the decision on the policy to be followed in international cooperation, the position of the A.S.A. had to be kept pending until after the appointment of the board.

Relation Between the A.S.A. and the U. S. Committee of the I.E.C.

The decision of the A.S.A. whether or not it should join the I.S.A. has been delayed by the efforts made to reach an agreement with the U. S. Committee of the I.E.C. to arrive at a unified organization for American participation in international standardization work. This goes back to the 1926 conference on standardization, where a resolution was presented to the effect that the I.E.C. might serve as a model for, or a nucleus of, a comprehensive "International Technical Commission."

Discussion between representatives of the U. S. Committee of the I.E.C. and the A.E.S.C. led to a resolution to the effect that a joint committee be appointed to develop a plan of a body for the international cooperation in all technical matters, including standardization. This resolution was accepted by the A.E.S.C. in July, 1927, but laid on the table in a meeting of the U. S. Committee of the I.E.C. held the next day.

No immediate action was taken thereafter, but in December, 1928, the question of cooperation between the U. S. Committee of the I.E.C. and the A.S.A., respecting international standardization in the electrical field and its relation to national standardization, was brought up again in the U. S. Committee of the I.E.C. by the N.E.M.A., and a resolution was adopted authorizing the President of the U. S. Committee to reopen negotiations with the A.S.A. A committee of six members representing the U. S. Committee has been appointed, consisting of Messrs. McClellan (chairman), Collens, Elden, Jewett, Low, and Thompson. The president of the A.S.A. has appointed a similar committee representing the A.S.A., consisting of Messrs. Skinner (chairman), Chapman, Gherardi, Maxwell, Nicholson, and Van Schaack, requesting the members to consider, jointly with the committee representing the U. S. Committee of the I.E.C., the establishment of a working arrangement between the two organizations, preliminary to a presentation of the whole problem of international relations of the A.S.A. to the board of directors.

Latterly, the U. S. Committee of the I.E.C. has aimed at a policy to the effect that in cases in which any of their projects is on a subject being dealt with by a sectional committee under A.S.A. procedure, the "adviser" of the U. S. Committee on this project will be identical with said sectional committee. This arrangement has been applied, for example, to the projects on: "Rating of Rivers," "Scientific and Engineering Symbols and Abbreviations," and "Thermal Markings for Electrical Apparatus."

A.S.M.E. Boiler Code Committee Work

THE Boiler Code Committee meets monthly for the purpose of considering communications relative to the Boiler Code. Any one desiring information as to the application of the Code is requested to communicate with the Secretary of the Committee, 29 West 39th St., New York, N. Y.

The procedure of the Committee in handling the cases is as follows: All inquiries must be in written form before they are accepted for consideration. Copies are sent by the Secretary of the Committee to all of the members of the Committee. The interpretation, in the form of a reply, is then prepared by the Committee and passed upon at a regular meeting of the Committee. This interpretation is later submitted to the Council of the Society for approval, after which it is issued to the inquirer and published in MECHANICAL ENGINEERING.

Below are given records of the interpretations of the Committee in Cases Nos. 625, 626, and 627 as formulated at the meeting on May 24, 1929, all having been approved by the Council. In accordance with established practice, names of inquirers have been omitted.

Case No. 625

Inquiry: Is it the intent of Par. P-200 that screwed staybolts be drilled with telltale holes, where they are in effect merely an extension of the through stays below the tubes of an h.r.t. boiler and are used to distribute the stress, as shown in Fig. 26?

Reply: It is the opinion of the Committee that there is nothing in the Code which requires the drilling of telltale holes in screwed stays used in connection with the attachments referred to, but the Committee recommends that this be done.

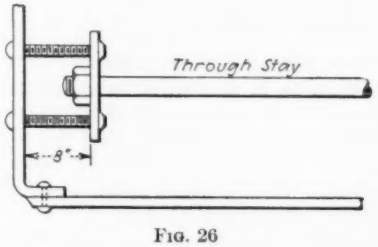


FIG. 26

Attention is called to the fact that the complete details of the structure are not shown in the sketch in Fig. 26 and that the reply is accordingly limited to whether or not the attaching stays should be drilled with telltale holes.

Case No. 626

Inquiry: Is it permissible, under the rules of the Code, to attach 6-in. nozzles to the shells and heads of boiler drums designed to operate at 600 lb. per sq. in., by inserting the necks through openings and flaring the ends inside, using autogenous welding inside for sealing purposes only? The necks of the nozzles are $6^{7}/_{8}$ in. outside diameter and are machined with a shoulder that rests on the outside of the shell, the entire drum being strain-normalized after the seal welding is completed.

Reply: The practice of inserting nozzle necks to openings in boiler drums and attaching them by flaring and welding is

(Continued on page 638)

The Conference Table

THIS Department is intended to afford individual members of the Society an opportunity to exchange experience and information with other members. It is to be understood, however, that questions which should properly be referred to a consulting engineer will not be handled in this department.

Inquiries will be welcomed at Society headquarters, where they will be referred to representatives of the various Professional Divisions of the Society for consideration. Replies are solicited from all members having experience with the questions indicated. Replies should be as brief as possible. Among those who have consented to assist in this work are the following:

ARCHIBALD BLACK,
Aeronautic Division
A. L. KIMBALL, JR.,
Applied Mechanics Division
H. W. BROOKS,
Fuels Division
R. L. DAUGHERTY,
Hydraulic Division
WM. W. MACON,
Iron and Steel Division
JAMES A. HALL,
Machine-Shop Practice Division
CHARLES W. BEESE,
Management Division
G. E. HAGEMANN,
Materials Handling Division
J. L. WALSH,
National Defense Division
L. H. MORRISON,
Oil and Gas Power Division
W. R. ECKERT,
Petroleum Division
F. M. GIBSON and W. M. KEENAN,
Power Division
WINFIELD S. HUSON,
Printing Industries Division
MARION B. RICHARDSON,
Railroad Division
JAMES W. COX, JR.
Textile Division
WM. BRAID WHITE,
Wood Industries Division

Management

Incentives for Creative Workers

Mg-1 What plans have been developed in industry for compensating creative workers for exceptional value produced?

(*a*) Wherever possible our organization has arranged that compensation shall be in proportion to values produced. We are not believers in the policy adopted by many large manufacturers, namely, that of requiring every employee to forfeit all right and title to his creative ideas upon associating himself with the company. Such a policy is felt to be not conducive to interesting the better types of men.

The reader is, of course, familiar with the plan of paying to the sales force a living wage as base pay, plus a small commission on net sales as an incentive; or to executives a salary plus a bonus based on profits.

When such a plan is considered for application to the creative worker (considering patentable ideas only), the case at first seems very different, but in reality the fundamentals do not differ greatly as far as evaluation of results is concerned. That is, the value of a patent-protected idea bears a relation to the profit produced from the idea which may vary greatly from year to year, making it futile to attempt to attach any valuation at the time the idea is disclosed or the patent assigned to the employer.

Since profit may be assumed to bear a fairly definite relation to volume of sales, the value to the employer of a patent-protected salable article in any given year bears a relation to the volume of sales which were built on that article during the given period. To the above extent the inventor may well be rewarded under the same type of compensation plan as is the salesman.

The dissimilarity becomes apparent when it is realized that the value of the inventor's idea continues in proportion to sales volume throughout the entire life of the patent—a period which may extend beyond his death, retirement, or discharge, while the productivity of the executive or salesman is considered to have stopped with the severing of his connection with the organization.

The writer's company feels that the policy of virtually taking employees into partnership via an incentive compensation plan can do much to produce high morale of employees and thereby add to the success of a business. If such a plan could be extended to the research and engineering workers with equally good results, the profits incident to the increased productivity would easily offset any increased compensation made payable to these workers.

However, there is a hesitancy to obligate an organization for even a small percentage of the earnings on protected ideas over a period which might extend beyond the employee's connection with the organization; yet any provision for stopping his extra or bonus compensation upon severance of the employee's connection gives to the management a possibility of avoidance of bonus payment which is quite obvious to the employee. A free discussion of this important subject should prove very valuable. (C. R. Alden, Research Engineer, Ex-Cello-O Tool & Manufacturing Co., Detroit, Michigan.)

(*b*) This question has come to the writer's mind repeatedly during his various studies of incentive plans, but he has found no definite plan for rewarding employees for patented inventions other than the system suggested by Mr. Alden. No doubt this is due to the fact that most companies consider a patent the property of the company, and that it is due to the efforts and resources of more than the individual who actually produces the idea. With the present tendency toward research departments, there seems little hope of developing plans, particularly for such individuals, and yet there is another tendency which may bring it about. Certainly employers are coming more and more to a fair and generous attitude toward all employees and toward creative employees in particular.

Mr. Alden's idea that inventors be rewarded on the profit-sharing basis is most interesting. The difficulty with such plans in the past has been that they were based on general merit. This is because specific contributions have been difficult to evaluate. Personally, the writer believes that some of the contributions can be evaluated, and that the profit-sharing plans will be more and more based on such evaluation. Prof. C. C. Balderston of the Wharton School of Finance has made a study of this particular type of incentive, and valuable experience may no doubt be found in his studies.

On the other hand, if the value of a patented invention can be definitely evaluated, it may be more satisfactory to set up the incentive plan with no direct connection to profits. If we were merely considering the incentive in its action after the fact, the profit-sharing principle would be sound, but it is one of the prime requirements of an incentive plan to give a definite offer in advance of the fact, and for this the profit-sharing principle is likely to have certain risks to the management. If we could be sure of no dull times, these risks would largely disappear but the fact is that we are likely to have at least relatively dull times despite our better control of the business cycle, and as long as we do have dull times, we shall find that maximum effort and maximum profits are not always concurrent. It would

seem, therefore, that the soundest procedure would be to base any incentive for patents on the evaluation of such patents as estimated at the time of their issue. There is no reason, however, why something parallel to a royalty might not also be provided, which would be in proportion to the later profits from the patent as such profits materialize.

The writer's advice is to study both the profit-sharing plans for executives and also the suggestion systems, so that the good points of the two types of plans may be brought into a common plan and the undesirable points of either plan avoided. (C. W. Lytle, Director, Industrial Cooperation, New York University.)

Questions to Which Answers Are Solicited

STRESSES IN OIL-WELL CASINGS

PT-1 What methods are recommended for determining the types of stresses causing failure of oil-well casings at depths of 2000 to 3000 ft.?

COAL FOR FORCED-DRAFT AND PREHEAT CONDITIONS

F-7 What coal specifications are recommended for forced-draft conditions such as are encountered in Taylor stokers operating on 400-deg. preheated air?

BENDING A HEAVY I-BEAM

M-3 It is proposed to bend a 9-in. I-beam of heavy section to a radius of 11 ft. 3 in. What methods are recommended to accomplish this without destroying the shape of the web of the beam?

Correspondence

CONTRIBUTIONS to the Correspondence Department of Mechanical Engineering are solicited. Contributions particularly welcomed are discussions of papers published in this journal, brief articles of current interest to mechanical engineers, or comments from members of The American Society of Mechanical Engineers on its activities or policies in Research and Standardization.

Wages of Engineers

TO THE EDITOR:

In MECHANICAL ENGINEERING for April, 1929, Mr. Thomas H. Normile asks why there are so few engineers working for themselves as compared with lawyers and physicians. In the first place, the term "working for themselves" is a misnomer, as no person in this civilized age can work for himself. Every one who is engaged in any form of activity for which he receives remuneration in one form or another is working for others. The term "engaged in independent practice" would probably better describe the condition to which Mr. Normile has reference. One often hears the term "their own boss" used. This also is a misnomer for the same reasons that the expression "working for themselves" is a misnomer. The only difference in this respect between the engineer in independent practice and the one in an organization is that the former has several bosses while the latter has only one.

The answer to Mr. Normile's question as to why only 9 per cent of the engineers are engaged in independent practice may be answered by giving some thought to the nature of engineering projects. Most projects requiring engineering skill can be carried on only by organizations consisting of scores and in some cases hundreds of engineers, and comprising a chief engineer, senior engineers, junior engineers, etc. Out of this small army of engineers there may be only two or three who are the owners of the business, or "working for themselves." If 90 per cent of all the engineers were engaged in private practice there would be only 10 per cent left to make up the technical staffs of the organizations, or only one engineer out of ten would have any technical assistance. There are a limited number of projects deserving the attention of engineers which could be carried on by one-man organizations such as these, and so after giving the matter a little thought it is easily seen why so few engineers are engaged in independent practice. In fact, the writer believes that this 9 per cent will tend to shrink to a smaller figure as time goes on and engineering projects become larger, requiring more extensive engineering organizations and taking the form of corporations instead of being individually owned. Of course, it would be very desirable for the engineers in these organizations to become financially interested in them through stock ownership. However, this would not fulfil what most of us have in mind when we feel that desire to become engaged in independent practice, and that is the elimination of bosses, fixed office hours, rigid vacation schedules, etc. The high percentage of lawyers and physicians in private practice is possible because most of the work of these two professions can be carried on by individual effort, and so large organizations are not required.

As to the advantages of being in private practice, Mr. Crosby Field submitted some data in MECHANICAL ENGINEERING for December, 1928, which show that for all engineers the income of those in private practice is about two and one-half times that of the engineers working on a salary in organizations. By including all engineers the average age of the salaried group is less than the average age of the group in private practice because almost all engineers pass through the first group, although some of them get into private practice later in life. For this reason the comparison is not on the proper basis. In the case of those engineers whose income is over $5000, those in private practice earn about 50 per cent more than those working on a salary. This comparison gives a more nearly accurate picture of the advantages of being engaged in private practice. The most interesting and useful study would be to base the comparison on the income of engineers in the two classes with the same length of experience.

There is no doubt that the economic status of the engineer is far below that of members of other professsions, such as the lawyer and physician. However, the cure cannot be brought about by engineers going into private practice, which would result in a great number of one-man organizations, for the reasons pointed out above. Not only does the engineer deserve more financial compensation, but he needs and should have more leisure in which to indulge in travel and other forms of cultural and physical recreation, thus preventing shattered nerves and shortened lives which are quite frequently the result of tense, single-track effort, a condition occurring too often among engineers and engineering executives who are responsible for the successful conduct of large enterprises.

In questioning the importance of personality among engineers Mr. Normile asks in the September, 1928, issue of MECHANICAL ENGINEERING if "such engineering talent" will solve the problems of preventing such catastrophes as the St. Francis Dam failure. One of the many requirements of an executive is a strong and high-type personality, and as the quality of the work of an engineering organization depends to a great extent upon the executive in charge, it will be seen that personality has an important but not necessarily a direct effect upon engineering work.

HERBERT B. REYNOLDS.[1]

New York, N. Y.

[1] Mechanical Research Engineer, Interborough Rapid Transit Co. Mem. A.S.M.E.

MECHANICAL ENGINEERING

A Monthly Journal Containing a Review of Progress and Attainments in Mechanical Engineering and Related Fields, The Engineering Index (of current engineering literature), together with a Summary of the Activities, Papers, and Proceedings of

The American Society of Mechanical Engineers

29 West 39th Street, New York

ELMER A. SPERRY, *President*
ERIK OBERG, *Treasurer* CALVIN W. RICE, *Secretary*

COMMITTEE ON PUBLICATIONS:
E. D. DREYFUS, *Chairman* F. V. LARKIN
W. A. SHOUDY, *Vice-Chairman* W. H. WINTERROWD
L. C. MORROW

PUBLICATION STAFF:
C. E. DAVIES, *Managing Editor*
FREDERICK LASK, *Advertising Manager*

Contributions of interest to the profession are solicited. Communications should be addressed to the Editor.

BY-LAW: The Society shall not be responsible for statements or opinions advanced in papers or . . . . printed in its publications (B2, Par. 3).

Reduction of Forest Fires

THE Society has a natural interest in all problems of conservation, but when the origins of waste and destruction lie within the field of engineering this interest becomes also a responsibility. Forest fires are one of the agencies of destruction in which the engineer has a responsibility. Sparks from locomotives and from wood-burning steam-generating plants in forest areas cause many fires, although investigation has shown that not all the fires so attributed are really the result of fuel-burning equipment in such areas.

An investigation of forest fires attributed to steam-generating apparatus is reported elsewhere in this issue. It shows among other things that strenuous efforts have been made to reduce the number of fires from this cause. Spark arresters have been developed which greatly reduce the menace if they are properly installed and maintained. The difficulty, however, lies in the improper maintenance of these devices, and in the ease with which they may be made ineffectual by those who operate the plants. It seems apparent that no technical research is necessary at this time. Education and vigilance in maintaining proper conditions provide the greatest possibility of reducing loss due to forest fires set by fuel-burning apparatus.

Tungsten Carbide Tools

THE first paper on tungsten carbide cutting tools which was presented to the Society was read at its annual meeting last December. The interest displayed in the new material was clearly demonstrated by the size of the audience, the type of men who had come to New York to learn about its properties, and the animated discussion which followed the paper. In May, at the Rochester meeting, reports on experiences with tungsten carbide tools were presented to an equally eager audience which was now asking how the new material had worked out in application. The technical press of the country gave generous and wide publicity to these reports, abstracts of which are published elsewhere in this issue. The complete reports will appear in the Machine-Shop Practice Section of the Transactions.

One of the noteworthy features of the situation which has developed as a result of the introduction of tungsten carbide cutting tools is the receptive attitude of both users and builders of machine tools. It is quite apparent that the consequences which may result from the use of the new material are being met squarely and promptly. The attitude is typical of this age of engineers, by whom change is accepted philosophically as being inevitable and an indication of progress.

Boiler-Feedwater Studies

THE Society is cooperating with other engineering societies in a joint research on boiler feedwater. The activities of the group which is engaged in the work are divided among nine sub-committees, each one of which is studying some phase of the subject of boiler feedwater. At meetings of the societies sponsoring the work the executive committee contributes papers in the field of its interests. It is now engaged in raising money for a campaign to undertake more actively a program of research.

As an indication of the importance of the committee's field of interest, the paper on "Recent Developments in Boiler-Water Embrittlement," published in this issue of MECHANICAL ENGINEERING, is offered. The author tells in considerable detail the troubles which a large organization experienced because of improper feedwater treatment. Many failures of boiler drums and tubes occur in boiler plants throughout the country through neglect of boiler-water conditions or improper treatment. Loss in money, in time, in property damage, and sometimes in life are the results of ignorance or neglect.

Our knowledge of boiler-water treatment permits us to guard against some of the more serious troubles. The operating engineer has become enough of a chemist to control the condition of the water in steam boilers, and with proper management and vigilance the life of tubes and drums may be extended. There are, however, many problems of corrosions, embrittlement, priming, and foaming still to be solved. This is the work of the joint research committee on boiler-feedwater studies. The program of the researches which the committee has proposed should have the active interest and support of every power-plant engineer.

Research in Sound

THERE is an awkward age in the development of machinery which gives meaning to the criticism of modern civilization that its mechanical features rob the world of charm. The enthusiasms of inventors blind them to the uncouth elements in undeveloped designs, and through ignorance of how to overcome these or because of a persistent following after the main idea, undesirable features become associated with valuable and useful devices to the extent that the good and bad points become complementary. Thus smoke, while preventable, has become an invariable concomitant of the burning of fuel, the lesser evil being accepted because of the greater good. Smoke and fire have been associated in men's minds since the days of Prometheus, but only a modern civilization burning fuel in large quantities, and thus making enormous quantities of smoke, has inquired into the possibility of smokeless combustion, and found that it is technically possible wherever it becomes economically essential.

Another greatly objectionable feature of modern life is noise.

Noise is associated with industry as inevitably as smoke is with fire. And just as the smoke of a hearth fire curling from a chimney adds cheer to a rural landscape, so the clang of an anvil in a village smithy is music to men's ears. But the smith's anvil becomes the steel mill, and the merry sound of builders' hammers grows into the incessant din of riveters. Industry has become too noisy.

Science has shown how to burn fuel without smoke. It will some day deal with the problem of preventable and objectionable noise. As a step forward in this program, the Applied Mechanics Division of the Society has appointed a sub-committee on sound whose activities will be divided into three major parts: (*a*) a study of preventable noise in industry, (*b*) a study of the control of sound in closed spaces, and (*c*) a study of the acoustics of musical instruments. The first efforts in these studies will be made toward the clarifications of the definitions of sound. What is a harmful sound? What is a noiseless machine?

The program of the Division inspires great hopes of valuable accomplishment in a field which has been too long neglected. Relief from such annoyances as smoke and noise fall in the class of luxuries in modern life, but the luxuries of yesterday become the necessities of tomorrow. Certainly if civilization continues its mechanical development, the economic and social value of noise reduction will receive more scientific and more serious study. The elimination of preventable noise will be an evidence of the passing from the awkward age into a maturity of a more perfect coordination of purposes and mechanism.

Mr. Employer:

TWO years ago attention was called in these columns to the problem presented by the young man graduating from college and entering industry. The taking of his place in the world of affairs is an event anticipated by the young graduate with the keenest enthusiasm. His contacts with this world are frequently disillusioning—sometimes tragic. The colleges have done their best. It is now up to the employer to receive the recruit to his business with a sympathetic and intelligent understanding. From *The Journal* of the Worcester Polytechnic Institute comes the following editorial addressed to the employer, which is reprinted through the courtesy of its editor, Herbert F. Taylor.

MR. EMPLOYER:

Certain young engineers are about to enter your organization. They are men of more than average intelligence and ambition, of more than ordinary promise. Your eagerness to employ them is an evidence that you recognize their potential worth. It is not within the province of the college to dictate the treatment that these recruits shall receive. The college has more than a passive interest in their welfare, however, and feels justified in making suggestions that may be mutually helpful.

These men—they are no longer boys—are serious minded for the most part, but they have a well-balanced sense of humor. Their training has made them alert, industrious, and self-confident. They possess no overweening idea that they "know it all," which is contrary to some conceptions of the young graduate.

Engineering education is a skilfully designed structure. Students progress from a substantial foundation of sciences and mathematics, along a framework of engineering fundamentals, to a superstructure of interesting and intricate problems. It frequently happens that graduation into industry means a plunge into a dull routine that offers few opportunities to exhibit highly trained analytical abilities. If this routine is a necessary step in their progress, as it frequently is, a careful explanation of the fact will create a healthier attitude.

Colleges cannot teach judgment; that comes from experience. These men have a fair amount of common-sense, and their judgment will develop in direct ratio to the amount of responsibility that is given them. It is well for them to make some mistakes if the penalties inflicted are not too severe. Make the penalty a heavier responsibility and see how they rise to it.

Young graduates need not be considered a dead loss during the period of finding themselves. Your business is all new to them, and they are eager to learn it. Idle drifting around the plant is not their idea of learning, however. They have been trained to work hard, and not having enough to do is their greatest source of discontent.

You have chosen men from the small group that has survived a long and arduous process of elimination. They are your investment for the future. Handle them intelligently, pay them all they are worth, give them a word of praise when it is merited, or of encouragement when it is needed. Some day they will step up and take your job, which is what you had in mind when you hired them.

Television and Mechanical Control

WE ARE so rapidly getting accustomed to take for granted new developments that it is becoming difficult to realize to what extent means of intercommunication are affecting the layout and operation of modern plants. It was telegraphy first and telephony afterward that made the present high-speed, high-density railroad operation possible. Any one who has sat for an hour or so at the desk of an executive of a big steel mill will realize that its operation would be practically impossible without the telephone.

All of this is particularly true of what is more and more becoming known as remote control, i.e., control of operation of a plant, be it converter substation, hydroelectric station, or mill, not by a man standing at a machine or switchboard, but by one located possibly many miles away. In hydroelectric work particularly there are many instances where plants could be profitably operated but for the fact that the output is too small to warrant the expense of personal plant attendants. In such cases, especially in Switzerland, methods have been worked out for distant-reading instruments and remote control of operation.

It was in this direction that Wensley of the Westinghouse Electric and Manufacturing Company developed his "mechanical man," which, for example, is not only capable of telling over the telephone in his own language at any time what the height of water is in a reservoir or the temperature in a heating operation, but will, when ordered to do so over the telephone, open or close a gate, move a switch in the desired direction to the desired extent, and perform other similar operations of limited control.

There is one thing, however, that none of these instruments hitherto has been able to do, and it is this one thing that is still making remote control of operation an exception rather than a rule. All the reading instruments, including the Wensley mechanical man, are capable of telling a few things that can be foreseen and for which they can be set. Should an emergency arise, however, the mechanical man has not yet been provided with brains enough to tell about it. For example, should lightning strike a distant substation, the mechanical man located there may inform headquarters that the substation has been struck, but he will not be able to explain in an understandable manner the amount of damage. He will not be able to discover a thief stripping copper from the generators, and in the case of a complete shutdown of the plant, in the majority of cases he will become dumbness itself.

Television, however, gives promise of being able to do these very things. If we can put a few television units throughout the plant and connect them properly to the master apparatus at the control station either by wire or wireless, it will be a comparatively simple proposition to actually see what is going on in the plant. It may of course require a somewhat modified layout of the plant, so as to give the mechanical "eye," naturally stationary, the ability to work with as high an angle of vision as possible, and it is entirely possible that some day, say, a tramp with a view to spending a night in a warm place and possibly pick up enough salable material with which to buy a few meals, will be met at the gate by a stentorian voice coming from a loud-speaking telephone and addressing him, "Hey you, keep away from here! No tramps

are allowed, and if I catch you here in five minutes I will send the police after you." The fact that the person speaking may be thirty miles away will not minimize the effectiveness of the threat, particularly if the police can be brought to the place of action in a 120 mile-an-hour airplane.

Mechanical engineers are truly living i a new world and will have to adapt their machinery and methods to the new conditions so as to profit by the availability of new and startlingly powerful instrumentalities.

Powdered Fuel and the Stoker Through German Eyes

LAST year P. Rosin of Dresden visited America and attended the Pittsburgh Coal Conference. He now describes his impressions in a German publication, the *Archiv für Wärmewirtschaft und Dampfkesselwesen* (vol. 10, no. 6, June, 1929). Some of his views may be of interest to American engineers in showing how the trained foreigner sees our conditions and what his reaction to them is on the basis of what he knows from those at home.

According to Mr. Rosin, many persons in Germany have asserted lately that powdered-coal firing is becoming obsolete. He did not notice any such thing in America. On the contrary he found a slight prevalence of powdered-coal firing in newly built large central stations, and he points out one material difference between German and American central-station practice which may have a bearing on the situation. In Germany more than half of the power generated comes from stations using brown coals as fuel, while in America lignites and brown coals are of little or no importance. American bituminous-coal-fired plants are in nearly every case located near water and often receive their coal from considerable distances and pay high freights—at times equal to the price of coal at the mine. This means that fuel is expensive and their main effort is to obtain as low a fuel consumption as possible, coupled with the ability to use all kinds of coal. Americans apparently find that powdered-coal fuel has a slight advantage over other forms when it comes to satisfying these two conditions. It is also significant that powdered fuel is predominantly used in America with coals having a high heat content, while in the case of lower-grade fuels the increase in cost due to the expense of drying and pulverizing them seems to be considered very seriously indeed. In Germany the migration of power plants to the waterside is not so pronounced. In the first place, their plants are smaller, and in the second place, large rivers, lakes, and ocean frontage are not as available in the industrial regions in Germany as they are in the United States. The tendency exists, however, and for a German it would not be safe to express too positive an opinion as to what will happen in the central-station field there as regards combustion systems.

It was only natural, says Mr. Rosin, to find at the conference an expression of the competitive spirit between pulverized-fuel firing and stoker firing. It appeared to him that this competition between powdered-fuel and stoker firing is carried on in a much friendlier spirit in the United States than in Germany, due probably to the fact that the leading combustion-engineering concerns in America build both types of firing equipment. In America it is not "either one or the other" ("Entweder-Oder") as is the case in Germany, but a question of considering the practical features of the two systems and arriving at a proper solution. Such problems as the increase of velocity of combustion, turbulence, study of aerodynamic conditions in the firing chamber, the use of primary and secondary air and air preheating, water cooling of furnace walls, ash handling, etc., are all being considered in order to arrive at a proper selection of the furnace type. Competition, Mr. Rosin remarks, is always a good thing for progress, but this does not mean that problems affecting all competitors together should be overlooked, or that because of competition there should be no cooperation toward their solution. The fundamental problem of all combustion methods is the burning of fuel, and our knowledge of it is still capable of vast improvement.

With some pride Mr. Rosin points out that practically all the papers dealing with powdered fuel come either from the United States or from Germany, these two countries appearing to be in the lead in the development of this particular field. He claims that Germany has progressed far in the field of drying and pulverizing of coal, the transportation of powdered fuel, and the use of powdered-fuel motors and locomotives, while America leads in the construction and operation of large powdered-fuel-fired boilers and the application of this type of fuel on shipboard. He believes that progress in this latter field deserves the particular attention of German engineering circles.

Teaching Advanced Mechanics

THE Applied Mechanics Division finds itself on the prefront of engineering advance. It adapts to the use of designers the principles and discoveries of science. Its methods are largely analytical, and it brings to the solution of its problems the powerful tool of mathematics.

The average man does not have a native capacity for original analytical work in mechanics. Many there are whose education provides them with a comprehension of a rigorous mathematical proof. The processes of mathematics are intelligible even if the reasons for employing them are obscure. Students in engineering colleges acquire this sort of knowledge of mechanics; they can read it even if they cannot always speak it.

When the student becomes a designer, however, his ability to read must be augmented by a facility in speaking the language of mechanics. Some of the larger industrial institutions that must rely upon original design in the development of their products have found it necessary to establish their own schools for teaching advanced mechanics and methods related to design. It is natural that these organizations should ask whether, perhaps, the engineering college is failing to fulfil its duty by not turning out students trained and competent in advanced mechanics and design. The question is an old one—that of the desirability of specialization. The answer to it seems clear. Undergraduate courses in engineering have no room for the teaching of advanced mechanics in such a way as to provide exactly the type of trained specialist that these industries need. For the most part, the effort would be wasted, except as a mental discipline, as few men enter these fields and few men have the native capacity or desire to succeed in them. With graduate study, on the other hand, the situation is quite different. Here specialization is sought, and the equipment in personnel which a modern university affords is available for the teaching of such subjects. There are also other ways in which colleges can and do serve industry in this sort of preparation. Cooperative arrangements have been worked out which are advantageous to industry and the college, and there are summer schools to which industry may send its most promising candidates.

At the Rochester Meeting of the Society this subject of advanced mechanics was discussed. Elsewhere in this issue will be found the two papers which the Applied Mechanics Division of the Society contributed to this meeting, together with the discussion which they provoked. They present the problem as industrial designers see it, and show what is being done in some places to teach this important subject.

The cooperative efforts of engineers to investigate problems of common interest to several branches have resulted in many joint activities of engineering societies. Such efforts result in codes of procedure, standards, and engineering researches.

Automobile Accidents—Their Cost

If blood is the price of Admiralty,
By God, we have paid it in full.—*Kipling*

THAT increased mechanical transportation on highways had to bring a growing list of accidents was to be expected. We are paying the price for living at a more rapid rate and for getting from place to place faster than ever before in the history of the world. The only question is whether or not the price we are paying is fair and reasonable, or whether, like drunken sailors, we are handing out our substance in lives without any consideration as to whether what we get is worth it.

According to apparently reliable statistics over 27,000 lives were lost in automobile accidents in the last year, and about thirty times as many have been injured. This means that with a registration of about 25,000,000 vehicles for the whole country, approximately one man is killed and thirty injured for every thousand vehicles registered. In Ohio a white cross is erected at the spot of every fatal accident, and as one travels the roads and observes these reminders of human carelessness, negligence, drunkenness, or simply bad luck, he cannot help thinking that if we were truly "efficient" and if all the states adopted the Ohio practice, we should know, for example, that when a motor company turns out, say, 2000 or 7000 cars a day, from two to seven white crosses will have to be made and erected to account for the people who will be killed by these cars, and hospital facilities for from 60 to 210 persons be provided for treating the injured.

Nevertheless, if a true balance were struck, it would be found that the automobile has saved countless thousands of lives by eliminating the horse from urban streets and thus practically doing away with what used to be the greatest carrier of disease, namely, the horsefly. In this way alone the introduction of motor transportation has probably saved hundreds of lives for every one that is lost in accidents. The question is only, are we doing everything necessary to reduce the number of accidents to that minimum, which, due to human frailties, will be always found to be irreducible.

Broadly, automobile accidents can be divided into four or five main classes. The first and probably easiest to eliminate is that resulting from the operator's being of an improper kind. Where no special examination for a driver's license has been introduced, deaf people, persons three-quarters blind, and released inmates of insane asylums have been found among those operating cars. Only a few weeks ago it was "discovered" (though how it could have escaped previous attention of the police and judicial authorities is certainly surprising) that the vast majority of boys in the Cleveland high schools, aged from fifteen years up, have been driving their automobiles to and from school. If a fifteen-year-old boy is entrusted with the management of a powerful car on streets as crowded as those of Cleveland, accidents should reasonably be considered not as exceptional but as legitimate consequences of a truly intolerable condition.

Another cause of accidents arises from the fact that our mechanical developments have far outstripped the consequently necessary social adjustments. To all practical purposes we have converted the streets of our towns into vast and poorly policed freight yards, but we have failed to remove from these yards those incapable of taking care of themselves under the new conditions. The result is that a substantial proportion of those killed in automobile accidents are of an age below ten years. This might be called the "Herod-ization" of our communities for the sake of progress.

In a further class of accidents we are deliberately paying in blood the price for getting there quickly. In the last few years, partly because of mechanical improvements in construction of automobiles and partly because our streets and highways have reached such a degree of congestion as to interfere with traffic, there has been a general tendency to speed up this traffic, which reached its highest expression in the Indiana law under which slowness of travel can be penalized by fines or jail sentences. Unquestionably in the hands of a good driver a modern automobile is as safe under normal conditions at 45 miles per hour as at 25 miles, provided the driver is sober and the automobile in good mechanical condition. There are, however, also unquestionably a large number of drivers whose nerve responses are too slow to meet with proper rapidity the emergencies that can arise at a speed of 45 m.p.h. Not all drivers are careful, and some are deliberately inclined to "hog" the road or to take chances, and a fairly reasonable chance at 25 miles an hour becomes something very different at 45 miles. Moreover, not every driver is sober, and a few drinks—not enough to make a man legally drunk—may be sufficient to warp the judgment to an extent that might not be excessively dangerous when traveling at 25 m.p.h., but would be fatal at 45. Finally, not all automobiles are in good shape; for example, the steering gear and brakes are not only subject to four times as great stresses at 45 as at 25 miles, but, what is more important, they wear out quickly as a result of the application of these stresses, and a car which may have been perfectly safe at the beginning of 5000 miles may be the cause of one of those apparently unaccountable accidents that are so frequent nowadays at the end of 10,000 miles.

The question is too big a one to be dealt with constructively within the limits of editorial comment, but engineers above all must realize that it will have to be dealt with sooner or later.

An Accurate Power-Recording Device for Use in Ore Crushing

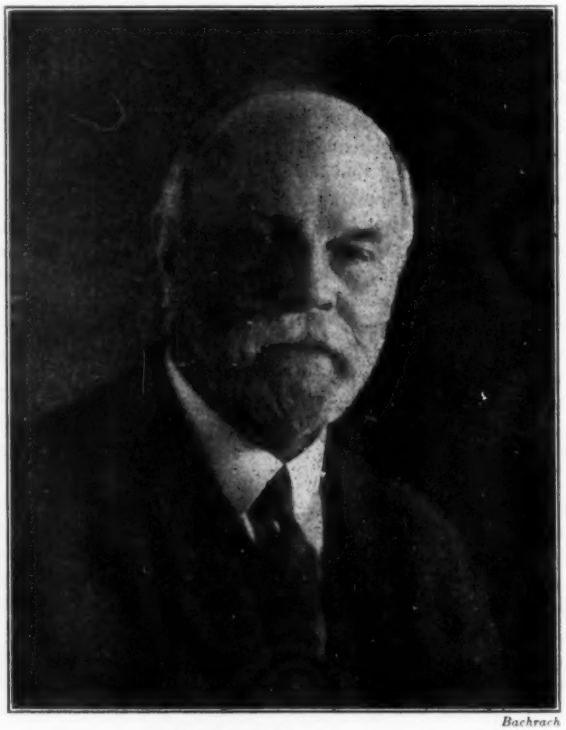
PRIOR to the time the United States Bureau of Mines, Department of Commerce, began its studies on crushing and grinding no accurate method had been devised for determining the amount of power required in crushing an ore to the proper size for efficient treatment by a concentration process or by a metallurgical process. As it was of the utmost importance to the Bureau in its study of ball-mill grinding to determine the power used in the mill, the metallurgists conducting the crushing and grinding studies at the Intermountain Experiment Station, Salt Lake City, Utah, in cooperation with the University of Utah, have developed an accurate power-recording device adapted from one used by Prof. H. E. T. Haultain of the University of Toronto, for measuring power input to rolls and which directly measures the work applied to the ball mill.

The apparatus is used to determine power to $^1/_{1000}$ horsepower and is independent of motor efficiency, belt friction, belt slippage, etc. It is constructed as follows: three tangential springs connect the pulley which rotates the ball mill; hence the greater the ball-mill load the greater the extension of the springs. The distance through which the springs extend is transmitted by a steel tape to an integrating meter. This meter is operated by two friction wheels in contact with a disk revolving at a definite speed ratio to that of the mill. The two friction wheels are connected to the meter through a differential gear, so that when centered on the disk both friction wheels revolve in opposite directions at the same speed and the counter stands still. Any displacement from the center of the disk results in an increased speed for one friction wheel and a decreased speed for the other. This change in speed is transmitted through the differential gear to the counter. By the calibration of the meter at various speeds by means of a Prony Brake and by means of static loads on the driving pulley the meter readings may be converted to horsepower.

Worcester Reed Warner

Sixteenth President of the A.S.M.E. Passes Away at the Age of Eighty-Three

AN OUTSTANDING personality has been lost to the engineering profession through the sudden death of Worcester Reed Warner, which occurred in the ancient town of Eisenach, Saxe-Weimar, Germany, on June 25, 1929. Mr. Warner left his home in Tarrytown, New York, early in May on his nineteenth European trip. The end came most unexpectedly, being due to shock. Mrs. Warner and his daughter Helen were with him. It will come as a distinct surprise to many to learn that this famous engineer and patron of science and the arts had attained the advanced age of eighty-three. To the last his physical and mental characteristics, as well as his mode of life, were those more apt to be associated with a well-preserved man of sixty.



Bachrach

WORCESTER REED WARNER

Mr. Warner—with his almost life-long associate Ambrose Swasey—was a founder of a concern known the world over as builders of accurate production machine tools, of some of the largest astronomical telescopes and mountings, and of other instruments of precision. With Ambrose Swasey he also shared the distinction of having been one of the original members of The American Society of Mechanical Engineers, as well as Past-President and Honorary Member of the Society. It is indeed a pity that Mr. Warner was not spared for another year to participate in two events toward which he eagerly looked forward—one the fiftieth anniversary of The American Society of Mechanical Engineers, and the other the fiftieth anniversary of The Warner & Swasey Company.

Worcester Reed Warner was born on a farm near the little village of Cummington, on the eastern slope of the Berkshires, between Northampton and Pittsfield, Massachusetts. Like the poet William Cullen Bryant who was also born in Cummington, Worcester Warner was of Mayflower ancestry, and the home farm had been cleared in the forest by four generations of Warners—among them a captain in the Revolutionary Army. Worcester Warner's father, Franklin J. Warner, was a more than ordinarily prosperous farmer, and Worcester evidently inherited his business ability from him. The mother, Vesta Wales (Reed) Warner, was a lover of books dealing with science, and had a marked taste for mechanical things. It is equally evident that Worcester inherited his mechanical ability from his mother, and that he drew his early inspiration in science from his mother's books.

The boy attended a district school in Cummington, and at the same time he had a contract with the school committee to build fires in the schoolhouse stove at eight o'clock every morning—the pay for this being $2 per term. This money went toward experiments carried on in a shop over his father's carriage shed. Among his early productions in this shop was a lathe built from odds and ends. In school he showed a keen dislike for the study of grammar, but an equally keen satisfaction in the study of history and of mathematics. At the age of nineteen he completed his schooling with a three-month term under G. Stanley Hall, who was then a student at Williams College, and who was during the last twenty-five years of his life president of Clark University in Worcester.

Worcester Warner had no liking for farming as a life work, so in the autumn of 1865 he set out for Boston, having saved up money enough to pay his fare. While visiting his uncle Worcester he saw a four-line advertisement by the American Safety Steam & Engine Company calling for a boy to work in the drafting room. He answered this, and being a green country boy he was disheartened to find about a hundred rather dapper city boys waiting in line. In spite of this George B. Brayton, the engineer, was attracted by the tall country boy, and after asking him some mechanical questions, he hired him for $5 per week—to the surprise and somewhat to the disgust of the president of the company, who evidently gaged boys by other standards.

In the spring of 1866 the offices were removed to Exeter, New Hampshire, and Mr. Brayton—who had cultivated Worcester Warner's acquaintance, much to the boy's advantage—took him along. There he worked in the shop as well as in the drafting room and office—still at $5 per week—and there he first met Ambrose Swasey, whom he described as "the brightest of the lot." After two years Ambrose Swasey went to the Grant Locomotive Works in Paterson, N. J., but becoming thoroughly homesick and discouraged there, he returned to Exeter. The two boys then decided to start out together, and after writing letters to several concerns they went to the Pratt & Whitney Company in Hartford, Conn., in the spring of 1869, and after Amos Whitney took them through the plant they went to work there.

In spite of the fact that there were some five hundred young men ahead of them, it was not two years before Warner and Swasey were given positions as foremen. Mr. Warner eventually had charge of the gear-cutting department, while Mr. Swasey had charge of a machine-tool-building department, and both engaged in an activity called "contract work," which played a large part in developing individual manufacturing talent in the old New England shops. Under this system the company furnished the men and the materials, and charged the labor against the contract. If the job was finished at a cost less than the contract, the contractor pocketed the difference as his profit. Otherwise the loss was charged against the next profit. The successful contractor had to be a close estimater, an able handler of men,

and a good mechanic. Warner & Swasey were notably successful in contracting, and though neither drew over $3 per day as salary, they managed to accumulate a joint capital of $12,000 during their eleven years with Pratt & Whitney.

Worcester Warner had a remarkable ability for making acquaintances, and his personality and appearance led to his being given charge of the Pratt & Whitney machinery exhibition in Boston in 1873. By the judicious operation of a fast screw machine next to an aisle, and by the liberal distribution of samples of its work, Mr. Warner kept a crowd around the exhibit and had the satisfaction of wiring to the plant, "You are awarded the first and only gold medal." He was later given charge of the company's exhibit at the Centennial in Philadelphia, spending six months on that assignment. It was during his later days with Pratt & Whitney that Mr. Warner made his first trip to Europe, taking a leave of absence in 1878 to do this. His uncanny ability to "get into places" was demonstrated on this trip when Charles Churchill & Company were unable to get him a pass into the famous Whitworth works, upon which he went to Newcastle "on his own" and so impressed the Whitworth officials that they conducted him through the whole "forbidden" plant.

In 1880 Worcester Warner and Ambrose Swasey decided to leave the Pratt & Whitney Company in order to establish a machine business of their own in the Middle West, where they felt there was a splendid field for such a business. With their joint assets of $12,000 they first tried to make a start in Chicago, but soon discovered that they were too far west to get the necessary skilled mechanics for a project such as theirs. They then investigated Cleveland, and being convinced by men like Thomas White, the sewing-machine manufacturer, that this growing industrial city was the ideal place for them, they established themselves there in 1881, building the first part of their present plant "way out in the country," now known as Carnegie Avenue near 55th Street. In those days the Euclid car line (horse cars) ended at 55th Street, and the two partners used to shoulder shaft hangers, boxes of bolts, etc., to carry them over to the new plant. In addition to their own $12,000 they borrowed $7000 from a willing Cleveland bank before their business got under way, and that was the only borrowed capital that they ever needed.

From that day to this the Warner & Swasey Company has been widely known in two seemingly entirely unrelated fields—turret lathes and astronomical telescopes. Worcester Warner drew his first astronomical inspiration from a book by Prof. C. M. Mitchell, called "Planetary and Stellar Worlds," which was presented to him by his parents. During his years at the Pratt & Whitney works he continued his astronomical studies with avidity, and became decidedly more than an amateur builder of telescopes. He was convinced that due to the size of telescopes, they had outgrown the "laboratory apparatus" type of mounting, and he proposed to have his company build instruments which should be real engineering structures, rigid in support, yet precise in their motions and convenient in their control. That his theory was sound is indicated by a brief mention of the Warner & Swasey achievements in this direction, such as: the 36-in. Lick telescope, the 40-in. Yerkes telescope, the 72-in. telescope for the Dominion of Canada, the 60-in. telescope for the Argentine National Observatory, etc. Their range finders, gun sights, field telescopes, etc., made for the United States Government were equally successful. The same stamina and precision were built into their machine tools, and in no small measure their widespread introduction into metal-working plants was due to the personality and business acumen of Mr. Warner. It is a remarkable example of the trust of one man in another that for twenty years Warner and Swasey conducted their business without any form of written agreement. The Warner & Swasey Company was incorporated in 1900, and these incorporation papers actually constitute their first written agreement. Mr. Warner served in various executive positions, including the presidency and the chairmanship of the board of directors.

In addition to his outstanding success as an engineer and manufacturer, Mr. Warner—during his thirty years of residence in Cleveland—became one of the leading men of that city in civic and financial affairs. He served as a director of the Guardian Trust Company, and of the Society for Savings; as a trustee of Western Reserve University and of Case School of Applied Science; as one of the early presidents of the Cleveland Chamber of Commerce and of the Civil Engineers' Club (now the Cleveland Engineering Society); and he was a member of the Union Club and of the University Club. In 1890 Mr. Warner married Miss Cornelia F. Blakemore, of Philadelphia, who was an able and popular associate in all of his activities from that time on. Mrs. Warner and their daughter, Miss Helen B. Warner, survive him.

To attempt to enumerate Mr. Warner's many benefactions is nearly as difficult as to enumerate the honors which he received for his attainments. He contributed liberally to educational institutions, and to churches, and among his contributions to the Cleveland Museum of Art is his collection of rare Chinese porcelains and other curios gathered during his travels. It may be fitting to mention here that Mr. Warner retired from active business in 1911, at the age of sixty-five, and was thereby able to devote the remaining eighteen years of his life to his favorite studies and to travel. At the time of his retirement he removed from Cleveland to his beautiful estate, Wilson Park, at Tarrytown, New York, where he maintained a fine private observatory and experimental workshop, and where he and Mrs. Warner did much entertaining. He never forgot his birthplace, and throughout his life he visited the isolated village of Cummington at least once a year. He not only gave the village a water system, but a fine Community House as well, and he helped to maintain a woodworking plant upon which the village depends to a considerable extent.

Mr. Warner was a fellow of the Royal Astronomical Society, and a member of the British Astronomical Society, the American Association for the Advancement of Science, and the Engineers' Club of New York. In 1897 he was given the degree of Doctor of Mechanical Science by the Western University of Pennsylvania, and in 1925 that of Doctor of Engineering by Case School of Applied Science.

Mr. Warner might almost be called one of the traditions of the A.S.M.E. He became a member of the Society in 1880—at its very beginning—and for forty-nine years he was a familiar and welcome presence at headquarters, at meetings, at the banquets, and on excursions. He personally knew literally hundreds of members, both old and young, and served as a fine inspiration toward what it is possible for an engineer to be. It is all too little to say that for years to come this genial presence will be profoundly missed in Society affairs. Worcester Reed Warner gave liberally of his time and of his talents in promoting the welfare of the A.S.M.E. He served as a Manager in 1890–93, and as President in 1897. In 1925 the Society had the privilege of creating him an Honorary Member, at which time Herbert Hoover was likewise recognized for his engineering achievements.

Worcester Reed Warner takes his place in history with such noted machine builders as Henry Maudslay, James Nasmyth, and Coleman Sellers. Like them he made headway in his chosen profession largely through his own efforts. Like them also he proved that a man might be practical and at the same time be a scientist. Like them also he proved that a good engineer is not necessarily a poor business man, and he showed how wealth may be so applied as to bring happiness and respect to the individual, and good to the world in general.—GUY HUBBARD.

Book Reviews and Library Notes

THE Library is a cooperative activity of the A.S.C.E., the A.I.M.E., the A.S.M.E., and the A.I.E.E. It is administered by the United Engineering Society as a public reference library of engineering and the allied sciences. It contains 150,000 volumes and pamphlets and receives currently most of the important periodicals in its field. It is housed in the Engineering Societies Building, 29 West 39th St., New York, N. Y. In order to place its resources at the disposal of those unable to visit it in person, the Library is prepared to furnish lists of references on engineering subjects, copies of translations of articles, and similar assistance. Charges sufficient to cover the cost of this work are made.

The Library maintains a collection of modern technical books which may be rented by members residing in North America. A rental of five cents a day, plus transportation, is charged. In asking for information, letters should be made as definite as possible, so that the investigator may understand clearly what is desired.

Book Reviews and Library Notes

DIE ABWÄRMETECHNIK, Vol. 3; Sondergebiete der Abwärmetechnik. By Hans Balcke. R. Oldenbourg, Munich and Berlin, 1928. Cloth, 6 × 9 in., 242 pp., illus., diagrams, 13.50 r.m.

The third volume of Dr. Balcke's treatise on waste-heat engineering is devoted to methods of using waste heat in several important fields. These include its use for obtaining distilled feedwater for boilers, for concentrating liquids, for drying, for humidifying workrooms, and for refrigerating. Other matters discussed are its utilization on freight steamships, the utilization of excess electric energy, and modern measuring instruments and methods. The three volumes form a very complete exposition of waste-heat engineering.

AIRCRAFT YEAR BOOK, 1929. Aeronautical Chamber of Commerce of America, Inc., New York, 1929. Cloth, 6 × 9 in., 484 pp., illus., portraits, diagrams, maps, $5.25.

This volume reviews the aeronautical occurrences of 1928 from various points of view. The operations of commercial organizations and the government are reported, technical developments are noticed, and a concise account given of all noteworthy events. Statistics, directories, airplane designs, etc. are combined to make a useful reference book for all those engaged in aviation.

GRUNDLAGEN UND GERÄTE TECHNISCHER LÄNGENMESSUNGEN. By G. Berndt. Second edition. Julius Springer, Berlin, 1929. Bound, 7 × 10 in., 374 pp., illus., diagrams, tables, 43.50 r.m.

This treatise, by the head of the Institute for Measurement and the Principles of Interchangeable Manufacturing at Dresden, surveys the scientific principles of measurement and the instruments for practical use. The evolution of the usual standards is described, and the methods by which shop and control standards of length are made and calibrated are discussed. Consideration is also given to the various types of gages and other measuring instruments that are used in industry, to their applications and precision. Physiological errors in measurement and the reference of the meter to the wave length of light are discussed in appendixes. The book contains a great amount of information on an important subject.

HISTORY OF MECHANICAL INVENTIONS. By Abbott Payson Usher. McGraw-Hill Book Co., New York, 1929. Cloth, 6 × 9 in., 401 pp., illus., $5.

This book is a systematic account of the development of the major mechanical inventions from their beginnings to the present time. Professor Usher's interest in the subject arises through its character as a basic element in economic history; as a result, he treats the subject in a broad way, with a minimum of technological detail, and with emphasis on matters of importance to society in general.

Introductory chapters discuss the place of technology in economic history and the process of mechanical invention. The early history of mechanical science and the mechanical equipment of antiquity are then described. Succeeding chapters trace the history of waterwheels and windmills, clocks and watches, printing, the textile industries, machine tools, and power production. A chapter is devoted to Leonardo da Vinci. Excellent illustrations and a good bibliography are included.

DER INDIZIERTE WIRKUNGSGRAD DER GASMASCHINE. By Hermann Schnell. DER EINFLUSS DES WÄRMEÜBERGANGES AUF DEN INDIZIERTEN WIRKUNGSGRAD DER GASMASCHINE. By Eberhard Hecker. (Forschungsarbeiten . . . heft 316.) V.D.I. Verlag, Berlin, 1929. Paper, 8 × 12 in., 33 pp., diagrams, tables, 6.50 r.m.

Designers and builders of gas engines will be interested in these two investigations. The first develops a theory for determining, more exactly than heretofore, the influence of the compression, composition of the fuel, and excess of air upon the thermodynamic efficiency of the gas engine, and gives curves showing the efficiencies for sixty cases which cover the used field. The second investigates the influence of heat transfer from the hot gases to the cylinder wall upon the thermodynamic efficiency.

INDUSTRIAL TRAFFIC MANAGEMENT. By Leslie Aulls Bryan. A. W. Shaw Co., Chicago, 1929. Cloth, 6 × 9 in., 392 pp., graphs, forms, $4.

Aims to present the established economic principles of the subject in a form suited for a college text and for use as a reference work in practice. Discusses general principles, the details of organizing and administering industrial traffic, and the legal considerations involved.

INTERNATIONAL CRITICAL TABLES of Numerical Data, Physics, Chemistry, and Technology, vols. 4 and 5. McGraw-Hill Book Co., New York, 1928–1929. Cloth, 9 × 11 in., 2 v., $12 each volume.

Two additional volumes of this great work will be welcomed by all scientific workers. Volume four contains phase-equilibrium data, osmotic pressures, and data upon surface tension, surface energy, and other properties of surfaces. Volume five has the numerical data of viscosity, specific heat, thermal conductivity, radiometry, photometry, and photography, and the properties of soaps and soap solutions. The data are based upon a critical study of all recorded observations and are indispensable to the investigator.

LAW FOR ENGINEERS AND ARCHITECTS. By Laurence P. Simpson and Essel R. Dillavon. West Publishing Co., St. Paul, 1929. Cloth, 6 × 9, 633 pp., $4.50.

This textbook has been specially written to give the student of engineering or architecture a knowledge of the fundamental

principles of law, illustrated by cases in which they are applied to those professions. The work is designed for the courses given at the University of Illinois.

The subjects treated include contracts, agency, workmen's compensation, mechanics' liens, property, regulation of public utilities, negotiable instruments, and sales. An appendix gives standard forms for building contracts, invitations to bidders, agreements between architect and owner, etc. The book will give the reader a knowledge of fundamental legal principles which will enable him to avoid many pitfalls and protect his interests.

LOW-TEMPERATURE CARBONIZATION, OR DISTILLATION, EXPLAINED. By Murray Stuart. Mining Publications, London, 1929. Cloth, 6 × 9 in., 57 pp., 4 s.

An experienced gasworks chemist discusses briefly and non-technically the aims of low-temperature distillation and the principles upon which the industry is founded. Dr. Stuart aims especially to emphasize the danger of attempting to generalize from any particular case, and the need for investigation before installing or investing in any process.

The history of the process, its principle, and its scope are set forth. Directions for calculating whether the process can work profitably are given, and the various types of processes are explained.

MEMOIRS AND ADDRESSES OF TWO DECADES. By Dr. J. A. L. Waddell. Edited by Frank W. Skinner. Mack Printing Co., Easton, Pa., 1928. Cloth, 6 × 9 in., 1174 pp., illus., portrait, tables, $5.

This volume supplements the collection of Dr. Waddell's professional writings prepared about twenty-five years ago by John Lyle Harrington. It contains seventy-five papers, together with a biographical sketch and brief summaries of the papers in the earlier volumes.

The papers now presented consist of addresses and contributions to periodicals during the last twenty-two years. These are grouped under eleven headings—the engineering profession, ethics of engineering, engineering literature, alloy bridge steels, economics, bridge construction, contracts, railroads, Chinese matters, and miscellaneous topics. The volume shows in a most interesting way the broad field of activity that Dr. Waddell has covered in his busy career, while his excellent style affords a useful model for every young engineer who wishes to write.

NOUVELLES ÉTUDES SUR LA CHALEUR. By Ch. Roszak and M. Véron. Dunod, Paris, 1929. Paper, 6 × 10 in., 765 pp., 208 fr.

This book, the work of two well-known French specialists in heat and refrigeration, is devoted to some questions that have heretofore been studied only superficially, as well as to certain new problems.

The opening chapter explains why the development of heating apparatus is still embryonic. The authors then set forth the relations between the production of heat and cold and the conditions of life on the earth. From this they proceed to a study of the different ways by which heat is propagated, by mixing, conduction, convection, and radiation. The results obtained in this theoretical study are then applied critically to modern steam generators, and directions in which improvement still seems possible are pointed out.

The remaining chapters discuss problems not connected with heat transmission, but of interest to the same engineers. They include a comparison of American and French rules for boiler construction, a discussion of district heating, and an account of Berthelot's method of hydrogenation, the basis of many recent processes for the synthesis of petroleum.

DIE ORGANISATION DER WÄRMEÜBERWACHUNG IN TECHNISCHEN BETRIEBEN. By Hans Balcke. R. Oldenbourg, Munich and Berlin, 1929. Cloth, 6 × 9 in., 312 pp., illus., diagrams, tables, 17.50 r.m.

The chief purpose of this book is to guide the power-plant operator in the selection of instruments, methods, and rules that will give him proper supervision and regulation of power-plant machinery. Methods of increasing efficiency of boilers, furnaces, gas producers, and steam engines are given. Special attention is given to automatic regulation.

POWER RESOURCES OF THE WORLD; potential and developed. By International Executive Council. World Power Conference, London, World Power Conference, London, 1929. Cloth, 6 × 10 in., 170 pp., tables, $4.25.

This important monograph has two purposes. It first aims to coordinate the available information on the coal resources, water power, and oil of the world, and on electric power production. Its second purpose is to indicate inequalities and omissions in the various systems for assessing power resources, and thus to further the adoption of uniform methods that will enable an accurate appraisal to be made.

The book brings together the best available estimate of our present and potential power resources. It also contains a bibliography of the power resources of the world, covering the period 1924 to 1928.

PRESENT-DAY LABOR RELATIONS. By Paul F. Gemmill. John Wiley & Sons, New York, 1929. Cloth, 6 × 9 in., 312 pp., $3.

Dr. Gemmill's aim has been to give a non-technical treatment of labor relations in this country which will give the average business man all that he will need to know about the leading types of collective negotiation.

The book discusses trade unionism, employee representation, and union-management cooperation. The purposes, methods, merits, and defects of each of these types are set forth concisely and illustrated by prominent examples.

PROFESSOR COKER'S PHOTO-ELASTIC APPARATUS. Adam Hilger, Ltd., London, 1929. Paper, 6 × 10 in., 28 pp., illus.

This pamphlet describes a method for investigating stresses in structures for which no mathematical solutions are available, by observations, under polarized light, on models made of transparent materials, such as celluloid or glass. The method is applicable to a great variety of engineering problems. The apparatus invented by Professor Coker is described in detail and the method of use explained.

RECENT ECONOMIC CHANGES IN THE UNITED STATES. By The Committee on Recent Economic Changes of the President's Conference on Unemployment. McGraw-Hill Book Co., New York, 1929. Cloth, 6 × 9 in., 2 vols., charts, tables, $7.50.

This, the third survey of a phase of our industrial life initiated by the President's Conference on Unemployment, is an analysis of post-war developments in American economic life, particularly those since recovery from the depression of 1920–21. The topics which were surveyed include industry, construction, transportation, marketing, labor, management, agriculture, price movements, money and credit, foreign markets and credits, and the distribution of the national income.

SIEMENS JAHRBUCH, 1929. By Siemens & Halske, & Siemens-Schuckertwerke. V.D.I. Verlag, Berlin, 1929. Cloth, 6 × 8 in., 644 pp., illus., portrait, diagrams, tables, 12 r.m.

The new issue of this handsome annual follows the plan of previous years, of presenting in non-technical language accounts of important scientific and technical advances recently made by the Siemens concerns. Contributions on telegraphy, electro-

chemistry, steam turbines, heavy-duty switchgear, and many other branches of electrical engineering are included. Of historic interest are several letters written fifty years ago by Werner von Siemens to his brothers, and papers on electric mine locomotives, Pupin coils, and automatic telephony.

WALZWERKSWESEN, vol. 1. Edited by J. Puppe and G. Stauber. (Handbuch des Eisenhüttenwesens.) Verlag Stahleisen, Düsseldorf; Julius Springer, Berlin, 1929. Cloth, 8 × 11 in., 777 pp., illus., plates, diagrams, tables, 85 r.m.

This is the first volume of the most exhaustive treatise on the rolling of iron and steel that has ever been published. The work has been prepared under the auspices of the German Society of Ironmasters, by a number of well-known specialists under the leadership of J. Puppe. When complete it will comprise four volumes.

The work is designed to be a complete treatise on rolling-mill practice. While special attention will be given to technical matters, economic and scientific matters will also be considered, so that the book will summarize completely our present knowledge in this field.

Volume one contains: the national and international economic importance of rolling mills, by Drs. Reichert and Buchmann; the historical evolution of rolling, by Dr. Johannsen; the constitution and properties of malleable and rollable iron, by Drs. Oberhoffer and Esser; the constitution of metals, by Dr. Hengstenberg; testing of materials, by Dr. Moser; specifications and standards, by Dr. Schulz; cost accounting, by Dr. Jordan; operating statistics and supervision, by Drs. Jordan and Rummel; the rolling process, by Dr. Koerber; rolls, by Dr. Emicke; and roll trains, by Dr. Puppe.

Succeeding volumes will discuss the rolling of various products, heating furnaces, conveyors, cranes, and other accessories.

A.S.M.E. Boiler Code Committee Work

(*Continued from page 627*)

not adequately provided for in the Code and a revision has been under consideration by the Boiler Code Committee to provide for such practice. A sub-committee of the Committee has recently submitted a report on the revision of Par. P-268 with this in view, and it is the opinion of the Committee that, if the proposed nozzle construction falls within the limits of this rule, it may be used with safe results. The section of the proposed revision pertaining to flared and welded connections is as follows:

b Flanged Fittings, Flared or Expanded Connections. On shells and on the spherical portions of the heads, forged steel nozzles may be inserted through an opening, flared over on the inside to an amount equal to at least the thickness of the necks of the nozzle up to an outside diameter which shall not exceed that given for unreinforced circular openings in Par. P-192. The diameter of the opening shall not be more than $^1/_{32}$ in. greater than the outside diameter of the part of the nozzle which passes through the shell. Such nozzles may be sealed by fusion welding provided the carbon content of the steel does not exceed 0.30 per cent and the diameter of the welded seal is at least $^1/_2$ in. less than the maximum diameter allowed by the rules for unreinforced circular openings given in Par. P-193.

When the thickness of a shell or the spherical portion of a head is greater than $^3/_4$ in., forged steel nozzles, the outside diameter of the neck of which does not exceed $4^1/_2$ in., may be attached thereto by inserting through an opening and expanding into the shell or head in accordance with the requirements for securing boiler tubes; the diameter of such an opening shall not exceed that given for unreinforced circular openings in Par. P-193.

All nozzles which are flared over on the inside of the shell or head except small nozzles where tube-seat grooves are provided, must be forged or machined with a shoulder which rests on a locally flattened surface on the outside of the shell or head to be formed by hot forging, hot flanging, or machining. When the outside of the shell or head is machined, the maximum cross-section of the metal removed in a plane passing through the opening and through the center line of the drum shall not exceed that allowed by the rules for unreinforced circular openings given in Par. P-193.

CASE NO. 627

Inquiry: Is it permissible, under the requirements of Pars. H-55 and H-108 of the Code, to use on steam heating boilers compound steam gages which indicate both pressure and vacuum readings so that there is no stop pin located at the zero point and the maximum travel of the pointer is less than 300 deg.?

Reply: The zero point on a compound-type steam gage has been considered to be the minimum of the range of pointer travel of the gage. It is the opinion of the Committee that on a compound-type gage where used for heating purposes, the stop pins or limit stops should be set at the limits of the gage reading at both the pressure and vacuum sides. A revision of Pars. H-55 and H-108 to cover this feature is under consideration by the Committee.

Synopses of A.S.M.E. Transactions Papers

THE papers abstracted on this and following pages appear in the current issue of the Fuels and Steam Power section of A.S.M.E. Transactions. This section has been sent to all who registered in the similarly named Division. Other sections are in the course of preparation and will be announced when completed, in later issues of "Mechanical Engineering."

FUELS AND STEAM POWER PAPERS

POWER DEVELOPMENT. By W. L. Abbott. [Paper No. FSP-51-1]

The author refers to several noteworthy achievements which have taken place during the past year. These, he says, were the result of progress made previously and the improvements were due to knowledge based on the accumulations of previous generations and centuries. None of the modern marvels spring fully developed from any brain. They are dependent on too many different arts for any one discoverer or inventor to encompass, and each must wait for the work of others. The game of engineering advancement is for scientists and engineers, but the winnings are for all.

DETAILS OF DESIGN AND CONSTRUCTION OF THE STREAM-FLOW POWER PLANT. By H. G. Roby. [Paper No. FSP-51-2]

Substructure problems that enter into the design of stream-flow power plants are discussed by the author. Passages carrying water to and away from the wheel should be unobstructed, but the building foundations must carry the weight of the generating equipment and of the building itself. Piers and columns must be inserted and these interfere with water-flow passages and cause turbulence and loss of efficiency.

One of the important advances in water-power practice is use of the propeller-type or high-speed runner. A late improvement in propeller design is an arrangement by which the pitch of the propeller blades may be changed to conform to the change in gate opening of

the heads. By adjusting the wheel to condition of flow at any given time, the efficiency is maintained at a high level. In a new hydro station put in operation at Louisville, Kentucky, which uses the propeller type, it is estimated that an output has been obtained 10 per cent greater than would have been possible with the Francis wheel.

POWER-PLANT SUBSTRUCTURE PROBLEMS. By J. C. Sanderson. [Paper No. FSP-51-3]

Varying conditions that are encountered in power-plant substructures are illustrated by discussing the problems that arose in the construction of four power plants at Mexico City, Pekin, Ill., Cincinnati, Ohio, and Chicago, Ill. The first was on soil of low bearing capacity, the second in water-bearing sand with a special cofferdam construction, the third required a deep foundation on water-bearing gravel, and the fourth was on a clay foundation.

DESIGN AND CONSTRUCTION OF SUBSTRUCTURES OF STEAM POWER STATIONS. By P. E. Stevens. [Paper No. FSP-51-4]

This paper discusses the substructures used under varying conditions in several localities. One located in an old river bed required the solution of many difficult problems. Another located 350 ft. from a river bank was constructed on a site which was overflowed to a depth of several feet during high-water stages. Still another developed an interesting method for solving the problem of wet excavation through pit and tunnel work.

METALS USED IN POWER PLANTS. By A. E. White. [Paper No. FSP-51-5]

This paper deals with metallurgy as applied to power plants. It is divided into two major sections, one concerning the metals used in this field, together with special processes for producing certain desired results, while the other considers the tests applied to metals in order to determine their suitability for the various required applications.

The metals considered in the first section are divided into two groups, ferrous and non-ferrous. Under ferrous metals, cast iron, wrought iron, plain carbon steels, and certain selected alloy steels are considered. The metals in the non-ferrous group considered are copper, lead, brass, bronze, babbitt, and monel. Special emphasis is placed on the field of use of each of these materials in power-plant work rather than on their characteristics. The special processes considered in the first section are welding, plating, and nitriding.

In the second section, the tests applied to metals made to determine their suitability for power-plant use are discussed. Among the tests considered are surface examination, including both visual and macroscopic, tensile tests, impact tests, hardness tests, metallographic examination, magnetic tests, X-ray examination, strain determinations, heat tests, fatigue tests, corrosion tests, corrosion-fatigue tests, and high-temperature tests.

THE CORROSION PROBLEM AS APPLIED TO POWER PLANTS. By H. S. Rawdon and K. H. Logan. [Paper No. FSP-51-6]

Some salient features of the corrosion problem that arise both inside and outside the power plant are discussed by the authors. In steam generation the problem is no longer one of the corrosion of iron by water but includes the corrosive attack of substances in the water, together with chemical reactions involving these impurities. Under the conditions of temperature and pressure that exist in boilers, many chemical reactions occur that create conditions very favorable to corrosion. Methods that are proving satisfactory in reducing corrosion are described.

Outside the plant, overhead transmission lines and supporting structures may be exposed to corrosive vapors. Much is being done to protect outside equipment from rapid deterioration. When power lines are put underground a different set of corrosion problems are encountered. Sheaths placed in ducts are subject to less corrosion from soil conditions, although it seems probable that some cable troubles attributed to stray-current electrolysis have some other origin.

USE OF POWER IN CHEMICAL INDUSTRIES. By Charles M. A. Stine. [Paper No. FSP-51-7]

A surprisingly large amount of power, both electrical and mechanical, is used by chemical industries. The author gives statistics showing the extent for various uses. One chemical plant cited, with a daily capacity of 1,000,000 lb. of steam in 24 hours, seven days per week operation, uses 50 per cent of the live steam directly in processing, 25 per cent for power generation, and the remaining 25 per cent for operating pumps, compressors, etc. The exhaust steam is used for heating buildings and feedwater.

X-RAY APPLICATIONS IN EVERY-DAY ENGINEERING PROBLEMS. By George L. Clark. [Paper No. FSP-51-8]

Uses of X-rays for examining and analyzing interior conditions of various materials used in engineering construction are outlined by the author. Metal castings are diagnosed for presence of internal gas cavities, sand and slag inclusions, pipe cavities, porosity, cracks, and metal segregation. More than 500 kinds of crystals have been analyzed to disclose knowledge of structure. The ductility and malleability of aluminum, copper, gold, silver, and the brittleness and hardness of chromium, tungsten, or molybdenum have been found related directly to the plan of building in the unit crystal. Many X-ray studies of non-metallic material are being made.

SYNCHRONOUS SELECTOR SUPERVISORY EQUIPMENT AND TELEMETERING. By C. E. Stewart. [Paper No. FSP-51-9]

A continuous picture of power-circuit conditions is given automatically by supervisory and telemetering equipments. The author describes one of the latest types of automatic supervisory equipments, its application to electric-power supervision, and its functioning with automatic telemetering equipment. The supervisory equipment is designated as the synchronous selector type and is accurate in its selective features, speedy in selection, and provided with a check-back feature for checking the selection before performing the operation.

TRENDS IN DEVELOPMENT OF ELECTRICITY-SUPPLY SYSTEMS. By W. F. Sims. [Paper No. FSP-51-10]

Simple and reliable electricity-supply systems are pointed to by the author as the present trend. Improvements in combustion conditions have brought about a marked reduction in the size of furnaces. Water-cooled furnace walls are becoming standard. Automatic combustion-control systems are gaining favor. Several installations, in the 1200-pound class, of considerable size are going ahead and in these the steam temperatures are conservative.

In the field of switching equipment, use of the truck type and of metal-clad switchgear are gaining favor. In railway substations there is a growing use of mercury-arc rectifiers instead of synchronous converters. Development and application of high-speed air circuit breakers is an important improvement in railway substation practice. Use of supervisory control has been extended and new equipment developed for this use is proving very reliable.

REFRIGERATION AND VENTILATION AS AIDS TO NATIONAL EFFICIENCY. By S. C. Bloom. [Paper No. FSP-51-11]

This paper describes developments in air cooling and air circulation that are being incorporated in modern office buildings. The amount of refrigeration required is large and current practice is to recirculate and recool 50 to 75 per cent of the air used. The volume of cooled air introduced is sufficient, usually, to change the air of a building 5 to 8 times per hour. The period during which cooling is required is but a small part of the year and current practice is to provide refrigerating equipment of capacity sufficient to handle the peak load. The power demand resulting is high and intermittent, and much expensive apparatus must remain idle a preponderant part of the time.

APPLICATION OF REFRIGERATION TO THE PRESERVATION OF FOODS. By A. J. Authenrieth. [Paper No. FSP-51-12]

This paper tells how the application of refrigeration to perishables has brought about a very marked betterment in the standards of living throughout the country. It has placed the products of a nation of diversified soils and climates in the home of every one. The health of the whole people has been safeguarded in increasing measure as more and better products are being made available. The applications of refrigeration to perishables have made possible the agricultural development of sections of the country which would otherwise lay as wasted, useless land.

RESEARCH AS APPLIED TO HEATING AND VENTILATION. By Samuel R. Lewis. [Paper No. FSP-51-13]

This paper gives the results that are being accomplished through various research programs that are being conducted in the field of heating and ventilation by the research laboratory of the American Society of Heating and Ventilating Engineers. Cooperative arrangements are in effect with many universities, colleges, and departments interested in this research work, and these enable the work

to be carried on at a cost very much less than would be necessary otherwise.

COMMERCIAL PROBLEMS IN STEAM-TURBINE DESIGN. By R. C. Allen. [Paper No. FSP-51-14]

This paper discusses developments in steam-turbine design. Concentration of power in modern turbines has led to an increase of operating stresses of turbine parts. The tendency now is toward higher blade speeds and reduced size and cost of machines. Manganese copper is used for blades of low stress and of small size; for the larger and more important blades, stainless steel is used. It can be forged and machined without difficulty.

CENTRIFUGAL-PUMP ECONOMICS. By A. F. Scherzer. [Paper No. FSP-51-15]

In this paper the author presents some developments in the theory of the centrifugal pump with which he has been connected and shows their application to pump practice. In reviewing the technical and theoretical aspects of the problem, he refers to the fact that the performance of the centrifugal pump is shown best graphically by the quantity-head curve. In the extensive centrifugal-pump literature existing there are to be found a number of theoretical analyses of the action of such pumps, all of which are based on somewhat similar assumptions. In each case the striking fact is the wide difference between the so-called theoretical curve and the one actually obtained by a test. To bring about any sort of an agreement it is necessary to assume in some cases large and disproportionate losses. To show this difference the author presents a chart showing the theoretical quantity-head curve and the actual curve obtained by a test of the pump. Around the point of zero discharge there was a discrepancy of about 100 per cent between so-called theory and practice. At or near the shut-off point the head actually obtained from the pump was nearly twice as much. A careful study of these matters resulted in the discovery of a surprising error in the derivation of the fundamental theory for the centrifugal pump.

Another interesting point brought out in the paper is that the use and the benefits claimed for guide vanes are founded on a misconception of theory. The same is true of the so-called volute or spiral casing into which the runner discharges the water.

The author states that the real function of the pump case is that of compelling the water to revolve in a more or less circular path. Thus the natural form of a case should not be volute or spiral, but rather a plain concentric circular case of constant cross-sectional area. Tests of a circular-case pump and a good design of the volute type showed a remarkable increase in head development by the former. At its point of maximum efficiency the circular-case pump developed an excess head of 50 per cent over a similar volute design.

COORDINATION OF INDUSTRIAL-PLANT AND CENTRAL-STATION POWER. By P. J. Gaudy. [Paper No. FSP-51-16]

In this paper the author discusses the generation of power for use of industrial plants. In general, he finds that central stations are able to deliver power as required by industrials cheaper than the latter can produce it themselves. An industrial can generate electric energy for power purposes profitably only when the utility does not maintain proper service or charge a reasonable rate or when the industrial has energy available in some form, for conversion to power, which is a by-product, or natural result of its major manufacturing process.

WELDING OF POWER-PLANT PIPING. By F. G. Outcalt. [Paper No. FSP-51-17]

In this paper the author discusses the possibilities offered for reducing costs of installation of power-plant piping, through welding. Erection problems are simplified when welded construction is used. Heavy fittings are eliminated and the piping is easier to handle and can be installed in less space. Many engineers are unwilling to use welded designs due to difficulty in telling when welds are not made properly. The author describes improved methods which insure that the work is of high quality and uniform character.

HIGH-PRESSURE TURBINE INSTALLATION OF KANSAS CITY POWER AND LIGHT COMPANY. By Edwin Jowett. [Paper No. FSP-51-18]

This paper describes the high-pressure turbine installation at the Northeast station of the Kansas City Power and Light Company. An operating pressure of 1200 lb. at the turbine throttle and a total temperature of 725 deg. are used. It is believed that the heat consumption of the station will be lowered 1830 B.t.u. per kw-hr. by the operation of the high-pressure equipment. With an annual output of 530,201,400 kw-hr. and with fuel at 67,000 B.t.u. for one cent the saving in fuel will result in an annual reduction in cost of $144,700. This is nearly three times the fixed charges on the difference in cost of the two installations.

POWER-PLANT MAINTENANCE AND ENGINEERING INSURANCE. By J. P. Morrison. [Paper No. FSP-51-19]

Various types of insurance policies for power plants are discussed by the author. Boiler-insurance policies are now written in blanket form, the principal sum being applied to payment of loss due to damage to any property of the assured, or to the property of others for which he may be liable.

Steam-turbine insurance protection is provided to cover not only the driving steam rotor, but also the generator, compressor, pump, or other driven objects forming a part of the turbine unit. Electrical generators driven by a steam turbine or by an engine may be protected by insurance independent of the driving unit.

The standard policy written by companies engaged in engineering insurance affords protection against loss due to direct damage to property of the owner, and of others for which the owner may be liable. It may be extended to include personal injuries and death to the public, as well as to employees in those states having no legislation to the contrary.

MODERN STOKER EQUIPMENT. By C. F. Hirshfeld and G. U. Moran. [Paper No. FSP-51-20]

This paper describes improvements that have been made in stoker construction to adapt them to modern needs. Improved types are constructed carefully, are capable of accurate control, and are used in large sizes. In choosing stoker equipment, the authors feel that generous allowance should be made above the apparent maximum requirements for fuel feed.

NOTE: Those who have not registered in the A.S.M.E. Fuels and Steam Power Division whose papers are abstracted on this and the previous pages, and who desire copies of any of these papers, may obtain them by using the form given below.

TO THE SECRETARY, A.S.M.E., 29 West 39th Street, New York, N. Y. Date.....

Please send copies of papers checked below:

Fuels and Steam Power	[FSP-51-1]	[FSP-51-2]	[FSP-51-3]	[FSP-51-4]	[FSP-51-5]	[FSP-51-6]
	[FSP-51-7]	[FSP-51-8]	[FSP-51-9]	[FSP-51-10]	[FSP-51-11]	[FSP-51-12]
	[FSP-51-13]	[FSP-51-14]	[FSP-51-15]	[FSP-51-16]	[FSP-51-17]	[FSP-51-18]
	[FSP-51-19]	[FSP-51-20]				

PRINT name (Important).....

Street Address..... City.....

THE ENGINEERING INDEX

(Registered United States, Great Britain and Canada)

Mechanical Engineering Section

THE ENGINEERING INDEX furnishes a Weekly Card Index Service of references to the periodical literature of the world covering every phase of engineering activity, including Aeronautic, Chemical, Civil, Electrical, Management, Mechanical, Mining and Metallurgical, Naval and Marine, Railway, etc. Items of particular interest to mechanical engineers are selected for presentation each month in this Mechanical Engineering Section. In operating The Engineering Index, The American Society of Mechanical Engineers makes available the information contained in some 1700 technical publications received by the Engineering Societies Library (New York), thus bringing the great resources of that library to the entire engineering profession.

Photoprint copies (white printing on a black background) of any of the articles listed in the Index may be obtained at a price of 25 cents a page. When ordering photoprints identify the article by quoting from the index item: (1) Title of article; (2) Name of periodical in which it appeared; (3) Volume, number, and date of publication of periodical; (4) Page numbers. A remittance of 25 cents a page should accompany the order. Orders should be sent to the Engineering Societies Library, 29 West 39th Street, New York.

AERIAL TRANSPORTATION

Accident Prevention. Problems in Flying, J. H. Doolittle. Am. Soc. Mech. Engrs.—Advance Paper, for mtg. May 27–30, 1929, 5 pp. Discussion of problems in increasing personal safety in flight; value of low landing speed, construction of airplane so that it crashes well, training for pilots, weather forecasting, instruments for blind flying, and fog flying problems are outlined; instruments for giving true altitude are described.

AERONAUTICAL INSTRUMENTS

Altimeters. Pressure Element of Constant Logarithmic Stiffness for Temperature Compensated Altimeter, W. G. Brombacher and F. Cordero. Nat. Advisory Committee for Aeronautics—Report, no. 310, 1929, 13 pp., 8 figs. Description of and laboratory data relating to special pressure element for altimeter constructed at Bureau of Standards for Bureau of Aeronautics of Navy Department; element consisted of metal bellows of sylphon type coupled to internal helical spring designed so as to have variable number of active coils; equations applying to springs and pressure elements of constant logarithmic stiffness developed.

Compasses. The Magneto Compass, F. P. Wills. Aero Digest, vol. 14, no. 5, May 1929, pp. 72, 74, 254 and 256, 4 figs. Descriptions of various types of magnetic compasses; errors to which magnetic compasses are subjected; earth-inductor compass consists of d.c. armature of non-magnetic material and brushes, and uses earth's horizontal component of field for excitation; principal advantages of earth-inductor compasses; magneto compass using permalloy developed by J. D. Tear of General Electric Co. discussed.

AIRPLANE ENGINES

Air Filters. Filter for Aircraft Engines. Airway Age, vol. 10, no. 6, June 1929, pp. 882, 1 fig. Description of air filter for airplane engines designed to prevent dirt from entering cylinders and to eliminate hazards of backfiring; device is developed by Air Maze Corp., Cleveland, and consists of alternate layers of flat and crimped wire screen of relatively coarse mesh, one layer of crimped wire placed next to flat and offset to crimped wire of opposite layer; results of tests with air cleaner attached to Wright R-975 engine.

Carburetors. See CARBURETORS.

Cowling. Drag and Cooling With Various Forms of Cowling for a Whirlwind Radial Air Cooled Engine, F. E. Weick. Nat. Advisory Committee for Aeronautics—Report, no. 313, 1929, 26 pp., 35 figs. Investigation in N.A.C.A. 20-ft. propeller research tunnel, of Whirlwind J-5 engine with several forms and degrees of cowling mounted on nose of cabin fuselage; cooling, drag, and flight tests made; effect of cowling on propulsive efficiency determined with metal propeller; cowling entirely covering engine reduces drag 2.6 times and seems entirely practical as regards both cooling and maintenance; with cabin fuselages substantial increase in high speed was obtained.

Diesel. A Summary of Lightweight Diesel Engine Development for Aircraft Purposes, C. H. Schowalter. Am. Soc. Mech. Engrs.—Advance Paper for mtg. May 27–30, 1929, 12 pp. Research in aircraft Diesel in past year; effect of present trend in carburetor-engine design; ideal theoretical efficiencies for both Otto and Diesel cycles at various compression and air fuel ratios; relations between both combustion and exhaust temperatures and compression ratios for both cycles; standardization of Diesel-engine fuels; recent Diesels for other than aircraft purposes; German engines; N.A.C.A. research; design consideration in aircraft Diesel. Bibliography.

The Aircraft Diesel Engine, L. M. Griffith and E. T. Vincent. Am. Soc. of Mech. Engrs.—Advance Paper for mtg. May 27–30, 1929, 21 pp., 2 figs. General considerations involved in developing Diesel engines of low weight and operating characteristics satisfactory to aircraft are discussed; possibilities of Diesel compared to present carburetted engines evaluated; technical problems analyzed; magnitude of recent advances and accomplishments pertinent to this application; probable type of aircraft most suitable for Diesel operation.

Geared. Some Aspects of Airplane Engines, A. Nutt. Am. Soc. Mech. Engrs.—Advance Paper for Mtg. May 27–30, 1929, 4 pp. Problems connected with operation of large air-cooled geared engines above 500 hp., which are necessary for larger transport machines and with single-engine mail and express airplanes; use of small-diameter radial engine, air-cooled, with gearing increases difficulty with cooling; water-cooled engine advocated; need for supercharging; of new cooling medium weight of air- and liquid-cooled engines is no longer argument in favor of air-cooled engine; Vee type of engine should appeal to commercial operator; exact increase due to new type of radial engine cowling has not been definitely determined.

Gliders. See GLIDERS.

Panhard Valveless. Panhard 500-hp. Engine Without Valves (Le moteur sans soupapes Panhard 500 cv.). Aerophile (Paris), vol. 37, nos. 5–6, Mar. 1–15, p. 81, 2 figs. Description of airplane engine with 12 cylinders arranged in 60-deg. V; steel cylinders are separated by sheet-steel envelopes for water; detachable cylinder heads carry spark plugs and starting valve; distribution to two-cylinder jackets is controlled by means of articulated connecting rod to two eccentric shafts; weight 460 kg.

AIRPLANE MANUFACTURE

Metal Construction. Handley Page Metal Construction. Flight (Lond.), vol. 21, no. 19, May 9, 1929, pp. 375–377, 19 figs. Some difficulties with which British aircraft industry are faced in developing all-metal construction for airplanes are discussed; steel fuselage construction developed by Handley Page; circular-section steel tubes joined by welding; where two tubes are jointed together sleeve is slipped over joint; duralumin wing construction; attaching fittings for inter-plane struts.

Metal Construction for Aeroplanes. Engineering (Lond.), vol. 127, no. 3305, May 17, 1929, pp. 606–607, 33 figs. partly on supp. sheet. Manufacturing methods employed by Vickers (Aviation), Ltd.; greater part of output of firm consists of all-metal machines; method of wing construction; system of spar construction; form of metal construction described has proved highly satisfactory in practice, weight saving amounting, on average, to 20 per cent in comparison with machine designed for same factor of safety and constructed in wood.

Metals in Airplane Construction (Metalle im Flugzeugbau), H. J. Pollard. V.D.I. Zeit. (Berlin), vol. 73, no. 17, Apr. 27, 1929, pp. 587–589, 21 figs. Excerpts from serial in Flight (Aircraft Engr.), vol. 20, from Jan. 26 to Nov. 29, 1928, entitled Metal Construction Development; details of riveted steel construction of frames, wings, rudders, and other parts of airplanes.

Welding. Development of Welded Aircraft Construction, S. C. Clark and W. I. Caston. Am. Soc. of Mech. Engrs.—Advance Paper for mtg. May 27–30, 1929, 4 pp., 6 figs. Trend toward welded steel tube construction for fuselages; present status of airplane welding; desirability of further research; work of Bureau of Standards; suggestions for improvement of present practice; standard specification that will insure hiring of good welders; selection and in-

NOTE.—The abbreviations used in indexing are as follows:

Academy (Acad.)
American (Am.)
Associated (Assoc.)
Association (Assn.)
Bulletin (Bul.)
Bureau (Bur.)
Canadian (Can.)
Chemical or Chemistry (Chem.)
Electrical or Electric (Elec.)
Electrician (Elecn.)
Engineer (Engr.[s])
Engineering (Eng.)
Gazette (Gaz.)
General (Gen.)
Geological (Geol.)
Heating (Heat.)
Industrial (Indus.)
Institute (Inst.)
Institution (Instn.)
International (Int.)
Journal (Jl.)
London (Lond.)
Machinery (Machy.)
Machinist (Mach.)
Magazine (Mag.)
Marine (Mar.)
Materials (Matls.)
Mechanical (Mech.)
Metallurgical (Met.)
Mining (Min.)
Municipal (Mun.)
National (Nat.)
New England (N. E.)
Proceedings (Proc.)
Record (Rec.)
Refrigerating (Refrig.)
Review (Rev.)
Railway (Ry.)
Scientific or Science (Sci.)
Society (Soc.)
State names (Ill., Minn., etc.)
Supplement (Supp.)
Transactions (Trans.)
United States (U. S.)
Ventilating (Vent.)
Western (West.)

spection of material; design and layout of welded joints; preparation for welding; inspection and test of work; future developments.

AIRPLANE PROPELLERS

Design. On Vortex Theory of Screw Propellers, S. Goldstein. Roy. Soc.—Proc., vol. A123, no. A792, Apr. 1929, pp. 440–465. Distribution of circulation along propeller blade when, for given thrust, energy lost in slipstream is minimum, is calculated exactly and compared with approximate Prandtl formula; formula for fluid velocities far behind propeller found, from which numerical values can be worked out by help of methods and numerical tables given; formula for distribution of thrust and torque, and for efficiency, when distribution of circulation is calculated.

AIRPLANES

Brakes. More About Aeroplane Brakes. Aeroplane (Lond.), vol. 36, no. 18, May 1, 1929, pp. 710–711, 3 figs. Two types of airplane brakes developed by Vickers (Aviation), Ltd.; compensated brakes for twin-engine machines consist of pilot's control, comprising lever-operated oil pump with reservoir, necessary pipe line, and brake unit mounted on axle of each wheel; in steerable brakes there is special distributing valve coupled to pilot's rudder bar which enables brakes to be used to assist steering on ground.

High-Altitude. The High Altitude Airplane. B. V. Korvin-Kroukovsky. Aviation, vol. 26, no. 20, May 18, 1929 (Aeronautical Eng. Sec.), pp. 78–84, 3 figs. Problems of engine cooling, propeller selection, and cabin design of airplane to navigate in stratosphere, are discussed; cabin made circular in cross-section; air compressed and fed into cabin by means of small compressure; advantages of navigating in stratosphere; no storms, snow, rain, or sleet; absence of clouds makes astronomical navigation day and night possible; freedom from convection currents and gustiness; effect of high altitude on safety in forced landing.

Spinning Characteristics. Slots and Spins, C. Harper. Aviation (Aeronautical Eng. Sec.), vol. 26, no. 20, May 18, 1929, pp. 70–76, 14 figs. Autorotation and forces which keep plane in spin, roll, yaw, and side slip are explained; forces due to inertia and gyroscopic couples in spin; bad design features including zero stagger, small gap-chord ratio, center of gravity aft, and high wing loading; physiology of spin; Handley-Page automatic and controlled slots; slot design features; tests; ice formation on slots; use of slots in recovery from spin. Abstract of paper read before Soc. Automotive Engrs.

Spinning Characteristics of Airplanes, M. Watter. Soc. Automotive Engrs.—Jl., vol. 24, no. 5, May 1929, pp. 474–478 and 527, 3 figs. Causes and nature of spinning of airplane and measures for prevention and recovery from spin are discussed; tests said to have shown that spinning is stable motion of rotation and that real dangers are in its instability; some new disposition of control surfaces so as to increase their effectiveness and to prevent shielding of rudder by body is important; possibility of using automatic leading-edge slots on horizontal tail-surfaces suggested.

Wings, Stresses in. Analysis of Torsional Stresses in Airplane Wings, A. Kartveli and E. Chagnaird. Aviation Eng., vol. 11, no. 6, June 1929, pp. 7–14 and 20, 9 figs. Description of method by means of which, through simple layouts and calculations, mutual action of spars can be computed in functions of elasticity of different elements; these forces being known, it is very easy to establish more accurate calculation of spars and rationally determine stiffness that cross members should possess; analysis of torsion in wing of thick airfoil is necessary in order to make rational distribution of material between spars; practical calculations given.

ALIGNMENT CHARTS

Construction. The Construction of Nomograms, A. L. Egan. Engineer (Lond.), vol. 147, no. 3828, May 24, 1929, pp. 565–567, 12 figs. Description of chart constructed by author which will solve any problem on compression and expansion of air, giving horsepower, both isothermal and adiabatic temperature changes and volume-weight ratios, almost at glance; essential principles are few, and attempt is made to set them out in simple form.

ALLOYS

Aluminum. See ALUMINUM ALLOYS.

Bearing Metals. See BEARING METALS.

ALUMINUM ALLOYS

Castings, Defects in. Pinholes in Aluminum Alloy Castings, N. F. Budgen. Metal Industry (Lond.), vol. 19, May 10, 1929, pp. 461–462. Pinholes due to shrinkage at solidification, and to occluded gases liberated at solidifications; latter played far greater part than shrinkage in causing pinholes; rate of solidification affects pinholes; while pure aluminum and 4 per cent aluminum-copper alloy have no pinholes, 8 per cent copper-aluminum alloy has profuse pinholes under certain conditions of melting. Abstract of lecture before Coordinating Societies.

AMMONIA COMPRESSORS

Sulzer. Sulzer Compressors for the Production of Synthetic Ammonia (Sulzer-Krompressoren zur Herstellung von synthetischem Ammoniak), A. Elsner. Zeit. fuer die Gesamte Kaelte-Industrie (Berlin), vol. 36, no. 1, Jan. 1929, pp. 1–8, 16 figs. Brief review of development of synthetic ammonia manufacture and different processes commercially employed; description of Sulzer compressor as employed in several plants; 6-stage gas compressor of 300 atmos. and 2000 cu. m. per hr. and 150 r.p.m.; auxiliary equipment, including suction, pressure, and safety valves; pistons and piston rings; cooling devices; etc. 4-Stage compressor is also described.

AUTOMOBILE ENGINES

Carburetors. See CARBURETORS.

Combustion Chambers. Combustion Control by Cylinder-Head Design, R. N. Janeway. Soc. Automotive Engrs.—Jl., vol. 24, no. 5, May 1929, pp. 498–512, 20 figs. Detonation and shock are subject to degree of control which can readily make possible use of compression ratios in neighborhood of 6 to 1 on commercial fuel without objectionable effects and without sacrifice of output; to obtain smoothness without loss of power, volume of charge must be so distributed with respect to firing position as to obtain as nearly as possible uniform acceleration in rate of pressure rise up to maximum rate, without excessive increase in explosion time.

Vibration. Controlling Torsional Vibration of Crankshaft Assemblies by Dampers and Modifiers, P. M. Heldt. Automotive Industries, vol. 60, no. 18, May 4, 1929, pp. 684–687 and 701, 4 figs. Factors influencing torsional vibrations of crankshafts are discussed; modification is possible by changing distribution of weight along crankshaft, but increasing engine speeds require addition of dampers; description of Chrysler full-range vibration damper, torsional vibration damper developed by T. J. Litle, Marmon Automobile Co., and harmonic balancer used on number of General Motors cars.

AUTOMOBILE PLANTS

Foundries. Chevrolet Foundry Methods Contribute to Saving in Scrap and Labor Cost, A. Taub. Automotive Industries, vol. 60, no. 20, May 18, 1929, pp. 778–779, 5 figs. Methods employed in Chevrolet foundry for producing new 6-cylinder engine are described; design of overhead-valve mechanism for the engine. Abstract of paper presented before Soc. Automotive Engrs.

Heat Treatment. Universal Heat Treating Unit in Operation at Packard Plant. Fuels and Furnaces, vol. 7, no. 6, June 1929, pp. 895–898, 5 figs. Three large furnaces with pushers and pullers interconnected with time controls form one continuous and automatic unit and can be adjusted for four operations in one, such as normalizing, heating for hardening, quenching, and drawing.

Materials Handling. Flow of Parts to Assembly Line Controlled by Move Orders, L. A. Churgay. Automotive Industries, vol. 60, no. 23, June 8, 1929, pp. 870–872, 5 figs. Description of methods of Chrysler Corp. for getting miscellaneous material to final assembly line when needed; standard loads carried in standard containers which are delivered to line on definite time basis; definite pick-up or distributing points established; set of record cards is shown. Abstract of paper presented before Am. Soc. Mech. Engrs.

Conveyors Add to Working Radius, F. L. Prentiss. Iron Age, vol. 123, no. 21, May 23, 1929, pp. 1405–1409, 6 figs. Description of recent installations of conveying equipment in plant of Willys Overland Co., Toledo; equipment makes feasible dispersion of departments, when space near-by is not available; complete system of overhead conveyors for handling automobile radiator shells through radiator-plating department, and gravity and conveyors in radiator-core assembly and testing departments.

AUTOMOBILES

Brakes. Improvement of Pneumatic Brakes (Vervollkommnung der Druckluftbremse), E. Manlik. Motorwagen (Berlin), vol. 32, no. 12, Apr. 30, 1929, pp. 243–245, 2 figs. Reference is made to recommendations of Westinghouse, Knorr A. G., Four-Wheel Brake Co., etc., none of which are entirely satisfactory; improvement of pneumatic brake must be based on a certain proportionality between pedal path and braking force, that is, guide valve must be actuated not only from pedal but also from braking pressure and this must be accomplished without detrimental reaction on pedal.

Trachsel Vacuum-Release Brake. Automotive Industries, vol. 60, no. 22, June 1, 1929, p. 835, 1 fig. Description of new Trachsel servo brake, invention of Swiss engineer, which makes use of vacuum merely for releasing brake, force of brake application being derived from coil spring within brake cylinder; brake can also be readily fitted to trailers and is applied automatically in case trailer becomes uncoupled from tractor.

Fuel Consumption. Specific Fuel Consumption Plotted Differently, E. A. Tschudakoff. Automotive Industries, vol. 60, no. 22, June 1, 1929, p. 833, 1 fig. New method of presenting relationship between specific fuel consumption, vehicle speed, and apparent traction resistance is briefly discussed; chart redrawn on basis of English units of measurement. Translated abstract of article published in Motorwagen, Mar. 10, 1929.

AUTOMOTIVE FUELS

Detonation. The Influence of Cylinder Design on "Pinking," G. B. Maxwell and R. V. Wheeler. Petroleum Times (Lond.), vol. 21, no. 540, May 18, 1929, pp. 903–904. Description of experiments made to determine how initiation of stationary wave can be prevented; turbulence of charge seems to inhibit formation of stationary wave, but reason is not clear; most important factor appears to be character of reactions proceeding in wake of flame; anti-knock such as lead tetraethyl does not seem to affect establishment of stationary wave; it affects maintenance of subsequent shock wave. Abstract of paper read before Inst. of Petroleum Technologists.

Flame Characteristics. Flame Characteristics of "Pinking" and "Non-Pinking" Fuels, G. B. Maxwell and R. V. Wheeler. Petroleum Times (Lond.), vol. 21, no. 541, May 25, 1929, pp. 948–950. Observations in previous research have been confirmed and extended by experiments with other fuels and blends of fuels; apparatus and method of experiment were same as described in previous paper, except that small fan was fitted centrally within cylinder; results are given.

B

BEARING METALS

Bronzes. Bearing Metals (Betrachtung einiger Werkstoffe fuer Lagerzwecke). Giessereipraxis (Berlin), vol. 50, nos. 20 and 21, May 19 and 26, 1929, pp. 77–79 and 81–83. Properties and composition of bearing bronzes are discussed; pure copper-tin alloys can be improved by small additions of lead, zinc, and phosphorus; results of tests with high-grade lead bearing bronzes carried out by Ajax Metal Co.

Testing. New Tests on Bearing Metals (Neue Untersuchungen ueber das NICO-Metall), Ackermann. V.D.I. Zeit. (Berlin), vol. 73, no. 6, Feb. 9, 1929, pp. 204–205, 1 fig. Comparative tests made to ascertain rate of wear of various alloys when subjected to dry frictional loads of various intensities; pressure-wear curves are reproduced; results show to what extent wear is reduced by substitution of nickel for copper in alloys examined.

BEARINGS

Lubrication. Grooving Bearings in Machines, G. B. Karelitz. Machine-Shop Practice (A.S.M.E. Trans.), vol. 51, no. 4, Jan.-Apr. 1929, pp. 21–28 and (discussion) 28–29, 30 figs. Design of bearing grooves is discussed; essentials of correct lubrication and conditions which it is desirable to establish by means of grooving; brief discussion of mechanism of lubrication; series of examples of grooving in classified number of applications; horizontal bearings for rotational continuous motion; bearings with oscillatory motion; guides with rectilinear motion.

BLAST FURNACES

Practice. First Report on Blast-Furnace and Plant Practice. Iron and Steel Inst.—Advance paper (Lond.), no. 2, May 1929, 25 pp See also abstracts in Engineering (Lond.), vol. 127, no. 3303, May 3, 1929, pp. 564–566, and Iron and Coal Trades Rev. (Lond.), vol. 118, no. 3192, May 3, 1929, pp. 645–648. Trend in United States toward ever-increasing capacities attaining economy by management; in Germany economy is attained by attention to selection and preparation of materials; selection, prepara-

tion, and handling of materials; furnace charging and top distribution; hot blast stoves; gas burning and surplus gas; blowing plant; power plant; pig-iron casting; plant layout; oxygen enrichment of blast. Bibliography.

BOILER FEEDWATER

Treatment. Preparation of a Serviceable Boiler Feedwater for High and Super-Pressure Boilers (Herstellung eines gebrauchsfaehigen Kesselspeisewassers fuer Hoch- und Hoechstdruckdampfkessel), W. Kaersten. Chemische Fabrick (Berlin), no. 3, Jan. 16, 1929, pp. 27–29, 6 figs. Soluble reaction products from treated waters have harmful effect on evaporators, on boiler itself, and even on superheater and turbines; water with low salt content, free from carbon dioxide and oxygen, is obtained by Balcke thermochemical system; carbonates are removed on plates or as sludge by settling after heating water at atmosphere pressure; water obtained is gas-free.

BOILERS

Heat Losses. Exhaust-Gas Losses (Der Abgasverlust), W. Gumz. Feuerungstechnik (Leipzig), vol. 17, no. 10, May 15, 1929, pp. 109–112, 4 figs. Shortcomings of formulas heretofore used in calculating exhaust-gas losses are set forth, and new formulas are derived; determination of auxiliary values; losses due to unburned fuels.

High-Pressure. High Pressures, Their Effect on Boiler Design, J. B. Crane. Power, vol. 69, no. 22, May 28, 1929, pp. 866–868, 2 figs. Comparison of various European and American designs of high-pressure boilers; forged drums, different apportioning of heating surfaces, and greater attention to circulation are some requirements of pressures over 1000 lb.

Steam Generators at Brighton. Engineer (Lond.), vol. 147, no. 3828, May 24, 1929, pp. 578–579, 4 figs. partly on supp. plate. Details of steam generators designed by W. R. Wood of Combustion Steam Generator Co. to produce at normal load, 100,000 lb. of steam per hr. at pressure of 350 lb. per sq. in. and temperature of 610 deg. fahr. with overload capacity of 125,000 lb. per hr.; generator is sort of rectangular box closed by tube surfaces at top, bottom, and sides.

Leakage. Significance of Boiler Leakages, E. Ingham. Mech. World (Manchester), vol. 85, no. 2210, May 10, 1929, pp. 436–437, 2 figs. Boiler leakage due to construction defects and to unsatisfactory conditions of working is discussed; imperfect bending and faulty riveting during construction; rising of pressure has been responsible for rendering boilers which were hitherto quite tight, seriously leaky; advisability of having all longitudinal seams of boilers made with butt joints instead of lap joints.

Natural-Gas-Fired. Largest Generating Station in South Fired With Natural Gas, W. C. Grant. Natural Gas, vol. 10, no. 4, Apr. 1929, pp. 54, 56, and 57, 6 figs. Brief description of plant of Louisiana Power and Light Co. at Sterlington, La., in Monroe gas field; when operating at full capacity it uses 2,000,000 cu. ft. of gas per hr.; four 1317-hp. Springfield boilers, convection superheaters; seven Duquesne natural-draft burners in each furnace, each burner with 105 gas tips with 3/16-in. fluted openings; estimated power production for 1929 is 425,000,000 kw-hr.

Pulverized - Coal - Fired. Pulverized - Fuel Burner for Lancashire Boilers. Engineering (Lond.), vol. 127, no. 3305, May 17, 1929, p. 609, 5 figs. on p. 614. Account of work of "B. and L." Powdered Fuel, Ltd., London, in converting two Lancashire boilers at Savill Brothers Brewery at Stratford, London, E., to burn pulverized coal.

Operation of Powdered-Fuel Installation at Calumet Station, W. H. Jensen. Associated State Eng. Societies—Bul., vol. 4, no. 2, Apr. 1929, pp. 123–126, 1 fig. Commonwealth Edison Co. data on two pulverized-fuel-fired steam-generating units; evaporation tests, and summary of operating results for three kinds of coal obtained with "bin and feeder" system of firing.

Thermodynamics of Pulverized-Coal Firing (Thermodynamik der Staubfeuerung), P. Rosin. V.D.I. Zeit. (Berlin), vol. 73, no. 21, May 25, 1929, pp. 719–725, 8 figs. Investigation shows fundamentals of pulverized-coal firing to be problem of velocity; duration of combustion; load conditions; size of combustion chamber and velocity of gases in their mutual relation are important factors in design; in practice possible loads depend on velocity of heat transfer to tested surfaces.

BORING MACHINES

Diamond-Tool. Diamond-Tool Boring Machines. Iron Age, vol. 123, no. 23, June 6, 1929, pp. 1577–1578, 4 figs. Description of Coulter diamond-tool boring machine, built by Automatic Machine Co., Bridgeport, Conn., for use of diamonds as cutting tools for finish boring to close precision limits at high production speed; machine is built single or double spindle and is used for finish boring either or both ends of automotive or airplane engine connecting rods, and wristpin holes in pistons, and for precision boring of die casting.

C

CARBON DIOXIDE

Compressors. New Cycle for Cold Vapor Machines (Neue Kreisprozesse an Kaltdampfmaschinen), H. Inokuty. Zeit. fuer die Gesamte Kaelte-Industrie (Berlin), vol. 36, no. 2, Feb. 1929, pp. 21–26, 9 figs. Discussion of theory and results of tests; it is known that efficiency of a cold vapor machine can be increased by multiple effect, that is, by two-stage compression in cylinder; author has sought to find incontrovertible theory of this process, and has conducted tests on carbon-dioxide machine to prove correctness of theory.

Thermal Properties. Thermal Properties of Carbon Dioxide in Gaseous, Liquid, and Solid State (Die thermischen Eigenschaften der Kohlensaeure im gasfoermigen, fluessigen und festen Zustand), J. Kuprianoff and R. Plank. Zeit. fuer die Gesamte Kaelte-Industrie (Berlin), vol. 36, no. 3, Mar. 1929, pp. 41–48, 2 figs. Temperature-entropy diagram is presented which is first to give characteristics of all three states; equilibria curves; specific volume; latent heats; steam tables and diagram. Bibliography.

CARBURETORS

Automobile-Engine. Carburetors and Their Significance in Modern Automobiles (Einiges ueber den Vergaser und seine Bedeutung fuer ein modernes Kraftfahrzeug). Automobil-Rundschau (Berlin), vol. 31, no. 9, May 1, 1929, pp. 187–188, 2 figs. Details of Orkan carburetors type U.M., with automatic fuel pump; acceleration curve is presented for acceleration with and without fuel pump.

Feeding. Feeding the Carburetter, W. F. Bradley. Autocar (Lond.), vol. 62, no. 1747, Apr. 26, 1929, pp. 821–822, 5 figs. Modern systems of ensuring adequate supply of fuel to engine are described; gravity, exhaust-pressure, and vacuum systems; designs of A.C. mechanically operated gasoline pump, auto-pulse magnetic pump, Stewart-Warner combined carburetor and electric fuel pump, and Bracke floatless carburetor with vacuum pump are explained.

Testing. Dynamometer Carburetion Runs on Curtiss GV-1570 Engines. Air Corps Information Cir., vol. 7, no. 630, Nov. 24, 1928, 5 pp., 5 figs. Description of investigation to determine by dynamometer tests characteristics of Stromberg Na-Y60 carburetor as fitted to Curtiss GV-1570 engine; attempt made to increase specific consumption at all points below 2300 r.p.m. and retain same full-throttle consumption; it is recommended that engine with standard setting be installed at torque stand, and acceleration and limiting flow of fuel on propeller load before back-firing results checked.

CARS

Dynamometer. A Well-Equipped British Dynamometer Car. Ry. Gaz. (Lond.), vol. 50, no. 22, May 31, 1929, pp. 815–817, 4 figs. Details of car and equipment used for testing locomotives and rolling stock on London and North Eastern Railway.

CASE-HARDENING

Cyanide. Case-Hardening in Cyanide Baths, F. Rapatz. Iron and Steel Industry (Lond.), vol. 11, no. 8, May 1929, pp. 241–242 and 251, 6 figs. Results of tests of Durferrite; structures of cases produced at 850 and 950 deg. cent. at various depths from surface; practical considerations; most favorable cementation temperature is about 850 deg. cent.; cases produced are readily hardened and conform to requirements; in case of small mass-produced parts process appears economically sound.

Depth Measurement. A New Method of Measuring the Thickness of Hard Cases, E. G. Herbert and P. Whitaker. Fuels and Furnaces, vol. 7, no. 6, June 1929, pp. 923–926, 3 figs. Development of means for applying differential method to measurement of case thickness which method takes into account three variables, case hardness, case thickness, and core hardness.

CHROMIUM-NICKEL STEEL

Testing. Tests of a Nickel Steel at High Temperatures, H. G. Tapsell and J. Remfry. Engineering (Lond.), vol. 127, no. 3305, May 17, 1929, p. 606, 2 figs. Results of experiments carried out at National Physical Laboratory for Engine Subcommittee of Aeronautical Research Committee on probable creep properties of high-nickel high-chromium steel at temperatures between 600 and 800 deg. cent.; intended for use in exhaust-turbine wheels for supercharger units. Abstract of special report, no. 15, of Department of Sci. and Indus. Research.

CONVEYORS

Automobile Plants. See AUTOMOBILE PLANTS.

Germany. A Small Conveyor Installation in a German Factory. Am. Mach., vol. 70, no. 21, May 23, 1929, pp. 818–819, 10 figs. Conveyors used in the progressive assembly of small engines are illustrated in eight halftones from Motorenfabrik Deutz, Cologne, each halftone being accompanied by brief description.

CRANES

Electric. A Large Transporter Crane. Elec. Rev. (Lond.), vol. 104, no. 2687, May 24, 1929, pp. 909–910, 2 figs. Details of crane erected at celluloid factory in Switzerland and carried out by Ateliers de Constructions Méchaniques of Vevey; supported by two towers 86 m. apart; area to be worked 5½ acres heaping up wood to height of 5 m.; difficulties in construction and erection have been avoidance of scaffolding to raise weight of 370 tons to 21 m. height and overcoming wind pressures; 500-volt three-phase 50-cycle electricity is used; design data of 5.5-ton crane are given.

Electric Grab Cranes (AEG-Zweimotoren-Steuerung fuer Greiferhubwerke). V.D.I. Zeit. (Berlin), vol. 73, no. 2, Jan. 12, 1929, p. 57, 2 figs.; see also Foerdertechnik u. Frachtverkehr (Wittenberg), vol. 22, no. 2, Jan. 18, 1929, pp. 30–32, 3 figs. Isometric drawings are given, showing driving and control gear employed in single-motor and double-motor grab cranes; in double-motor equipment each motor is of half total horsepower required for hoisting; interlocked controllers are used, so that two motors share equally duty of hoisting, but one motor and winch can be used alone to close and open grab.

D

DIES

Punching. Cromovan Solves Kelsey-Hayes Brake Drum Die Problems. Automotive Industries, vol. 60, no. 22, June 1, 1929, p. 851, 2 figs. Use of Cromovan in plant of Kelsey-Hayes Wheel Corp., Detroit, for dies employed in making brake drums; for severe operating conditions where great stresses are imposed on dies, as well as for hot working, Firth-Sterling products prove satisfactory; reconditioning done once during life of die.

DIESEL-ELECTRIC POWER PLANTS

Costs. Diesel Engine Power Costs. Nat. Elec. Light Assn.—Serial Report, no. 89–38, Apr. 1929, 7 pp. Diesel-engine power costs are shown in 8 tables covering operating data and unit cost of Diesel-engine generating plants, fuel and lubricating-oil consumption and maintenance costs of Diesel-engine plants, operating data of mechanical-drive Diesel-engine installations, investment costs of Diesel-engine plants, investment cost of mechanical-drive Diesel-engine installations, and attendance labor costs in Diesel-engine plants; short form of questionnaire; fuel and lubricating-oil consumption maintenance.

DIESEL ENGINES

Airplane. See AIRPLANE ENGINES, DIESEL.

Design. A Survey of Diesel and Semi-Diesel Practice. Gas and Oil Power (Lond.), vol. 24, no. 280, Jan. 3, 1929, pp. 76–78. History and development of heavy oil engine; airless injection; trend of modern oil engine practice is now to eliminate hot bulb and by extended water cooling in breech end region to reduce uncooled interior of combustion areas, combustion being effected by increase of compression cartridge ignition and improvements in general cylinder design; success of two-cycle oil engine depends now to large extent on high-class workmanship; systems of starting from cold.

Heat Transmission. The Transfer of Heat in Reciprocating Engines, A. Naegel. Engineering (Lond.), vol. 127, no. 3305, May 17, 1929, pp. 626–630, 26 figs. Results of investigations of Sulzer Diesel engine; reference is made to work of Eichelberg, who was first to show that, in spite of small temperature varia-

tions, heat fluctuation was comparatively great, and also that, due to fluctuations in quantity of heat, stresses in service may, under certain conditions, become dangerous; numerous temperatures and distribution charges are presented; appendix contained notation and methods of deduction.

Peak-Load. Diesel Engines as Stand-By and Peak-Load Engines in Steam Power Plants (Dieselmotoren als Zusatz- und Spitzenkraftmaschinen in Dampfkraftwerken), M. Gercke. Waerme (Berlin), vol. 52, no. 18, May 4, 1929, pp. 373–377, 5 figs. Technical and economic aspects are discussed; effect of Diesel engine fuel economy in steam plants; practical results obtained in English Diesel peak-load power plant; influence of cost of cable on electricity-supply rate making; underground peak-load Diesel plants in municipal electricity-supply districts; example of such installation in London.

E

ELECTRIC FURNACES

Steel Making. Coreless Induction Furnaces. Metropolitan-Vickers Gaz. (Manchester), vol. 11, no. 192, Mar. 1929, pp. 228–231, 5 figs. Electric steel-melting furnaces of Metropolitan Vickers Co. of 5 cwt. and 350 lb.; electric motor-generator equipment for 5-cwt. type of 160 kw. capacity, 1000 volt 500 cycles; performance data.

ELECTRIC WELDING, ARC

Atomic Hydrogen. Recent Developments in Atomic Hydrogen Welding, P. P. Alexander. Am. Welding Soc.—Jl., vol. 8, no. 5, May 1929, pp. 48–49. Applications of atomic-hydrogen welding briefly discussed; processes adaptable to welding of thin materials or special alloys and low melting-point alloys; hydrogen protects alloys from oxidation. Paper presented before Indus. Heat. Conference.

ENGINEERING

Probability Theory in. Acceptance Tests and Probability Calculation (Abnahme und Wahrscheinlichkeits-Rechnung), K. Daeves. Stahl und Eisen (Duesseldorf), vol. 49, no. 18, May 2, 1929, pp. 645–653, 13 figs. It is claimed that ideal testing of finished product at maximum stress is seldom possible; increasing influence of probability calculation is pointed out; experimental results in form of frequency curves; effect of tolerance specifications; disadvantages of rigid maximum and minimum specifications; formulation and effect of normal acceptance conditions with respect to producer and user.

F

FANS

Propeller-Type. Modern Propeller-Type Fans (Der mechanische Wirkungsgrad neuzeitlicher Schraubenventilatoren und der Einfluss ihrer Fluegelformen), Maercks. Bergbau (Gelsenkirchen), vol. 42, no. 1, Jan. 10, 1929, pp. 1–5, 5 figs. Whereas older types of propeller fans showed efficiencies of from 20 to 30 per cent, values from 42 to 45 per cent are realized in modern designs; author presents test data for two fans with steep and flat-blade pitch, respectively, and shows that flat blades overcome higher resistance than steep-pitch blades at given speed; excluding capital charges, running cost of electrically driven fan, in case considered, is about one-sixth that of fan driven by air turbine.

FLOW OF FLUIDS

Turbulent. Heat Exchange in Turbulent Flow of a Liquid or a Gas (Ueber den Waermetastausch bei turbulenter Stroemung einer Fluessigkeit oder eines Gases), S. Tarassemko. Physikalische Zeit. (Leipzig), vol. 30, no. 9, May 1, 1929, pp. 252–256, 1 fig. Theoretical mathematical discussion; equations for various values of Prandtl coefficient.

Viscous. On the Steady Motion of Viscous, Incompressible Fluids; With Particular Reference to a Variation Principle, C. B. Millikan. Lond., Edinburgh, and Dublin Philosophical Mag. and Jl. of Science (Lond.), vol. 7, no. 44, Apr. 1929, pp. 641–662. Discussion of general equations for steady motion of viscous, incompressible fluid from point of view of minimum or variation principle; except in certain exceptional cases equations of steady motion of viscous, incompressible fluid cannot be deduced from variation principle involving Lagrangian function containing only velocity components, their first-order space derivatives, and possibly functions of coordinates.

FLOW OF WATER

Pipes. Pressures in Manifold Pipes, M. L. Enger and M. I. Levy. Am. Water Works Assn.—Jl., vol. 21, no. 5, May 1929, pp. 659–667, 4 figs. Report on experimental study made in Hydraulics Laboratory of University of Illinois; formula for variation of pressure in pipe with long narrow slot.

Streamline Flow Through Curved Pipes, E. V. Appleton. Roy. Soc.—Proc., vol. A123, no. A792, Apr. 1929, pp. 645–663. Author describes tests recently carried out in Engineering Department at King's College, London; to define influence of curvature upon law of resistance for range of Reynolds numbers up to about 9000; diameter of pipes, tested with water or oil, varied from 0.298 to 1.032 cm., diameters of coils from 15.62 to 610.5 cm.

FOUNDRIES

Automobile Plants. See AUTOMOBILE PLANTS.

Materials Handling. Conveyorized Production in German Foundries (Bandarbeit in deutscher Giessereien), K. Brieger. Giesserei Zeitung (Berlin), vol. 26, no. 10, May 15, 1929, pp. 282–290, 24 figs. Outline of status of continuous production in German foundries; possibilities of mechanization are visualized by examples of actual plants in operation.

Recent Developments in Hoisting and Conveying Equipment in Foundry Practice (Die neuere Entwicklung der Hebe- und Transporttechnik fuer den Giessereibetrieb), H. Hermanns. Giesserei Zeitung (Berlin), vol. 26, no. 10, May 15, 1929, pp. 265–272. Economic importance of foundry-transport equipment is pointed out; design of conveyors for handling of raw material; details of actual installations and comparison of different designs; comparison of German and American materials-handling equipment.

FURNACES, MELTING

Gas-Fired. A New Type of Brass Melting Furnace, A. Forward. Metal Industry (N. Y.), vol. 27, no. 5, May 1929, pp. 237–238, 2 figs. See also Am. Gas Assn. Monthly, vol. 11, no. 5, May 1929, pp. 269–272, 4 figs. Description of brass melter consisting of revolving metallic retort externally fired and enclosed in shell heavily insulated, and refractory lined for heat concentration; atmospheric control and fuel conservation; ten gas burners, five on each side; furnace developed through research sponsored by American Gas Assn. and American Gas Furnace Co.

G

GAS ENGINES

Study of. Complete Thermodynamic and Experimental Study of a Gas Engine (Etude thermodynamique et expérimentale complète d'un moteur a gaz), A. Duchesne. Revue Universelle des Mines (Liége), vol. 1, nos. 3, 4, 7, and 9, Feb. 1, 15, Apr. 1, and May 1, 1929, pp. 61–66, 98–105, 196–208, and 265–270, 13 figs. Feb. 1: Measurement of gas and air discharge. Feb. 15: Diagram is presented of specific heats of gas. Apr. 1: Calculation of heat exchange during explosion; diagram of heat exchange. May 1: Calculation of expansion and compression.

GAS TURBINES

Lorenzen. Combined Exhaust-Gas Turbines and Supercharger. Engineering (Lond.), vol. 127, no. 3303, May 3, 1929, p. 566, 2 figs. Description of combination of exhaust gas turbine and compressor constructed by C. Lorenzen, Berlin, for supercharging gasoline engines; turbine acts also as efficient silencer; fan or impeller, which supplies supercharging air, forms central portion of turbine rotor; turbine blades are hollow and whole of air discharged from impeller passes through these blades; by this arrangement blading is kept cool while supercharging air is heated.

GEAR CUTTING

Cutting Lubricants. Analysis of Cooling Oils Used in Gear Manufacture (Untersuchung der Kuehloele bei der Zahnradbearbeitung), A. Wallichs and K. Krekeler. V.D.I. Zeit. (Berlin), vol. 73, no. 19, May 11, 1929, pp. 643–647, 12 figs. Results of tests, made at Machine Tool Laboratory of Aachen Institute of Technique, of rape and mineral oils used in Maag gear-cutting process; physical and chemical properties of oils, their effect on corrosion, etc.

GEARS AND GEARING

Design. Load Distribution in Gears Improves as Tooth Contacts Increase, R. V. Baud and R. E. Petersen. Automotive Industries, vol. 60, no. 23, June 8, 1929, pp. 873–878, 20 figs. Method is presented for solving load-division problem analytically; by photoelastic tests some general stress relations are determined for gears in which number of teeth carrying load varies; experiments made to show effect of contact ratio in magnitude of stresses; when more than one pair of teeth of gear are in contact, load is not divided equally but depends on deflections of teeth; increase in contact ratio produces more favorable load and stress cycles. Paper presented before Am. Gear Mfrs. Assn.

Helical. Helical Gears, T. P. Colbert. Machine-Shop Practice (A.S.M.E. Trans.), vol. 51, no. 4, Jan.-Apr. 1929, pp. 9–11, 4 figs. Charts and formulas designed to make computing of spiral gears less difficult are given; angle of helix is expressed for both gears in terms of angle on driver gear; this angle is made to appear as angle of wedge by defining it as angle between tooth and direction of motion of pitch circle.

Ratchet. The Humfrey-Sandberg Ratchet Gear. Engineering (Lond.), vol. 127, no. 3305, May 17, 1929, pp. 609–611, 6 figs. Details of improved form of ratchet mechanism now being developed by Humfrey-Sandberg (Sales), Ltd.; in this mechanism, toothed wheel and pawl employed in ordinary ratchet gear are replaced by Humfrey-Sandberg clutch, which give positive drive without backlash or shock, is silent in operation, extremely neat and compact, and completely enclosed, so that it is unaffected by corrosive or abrasive atmospheres.

Planetary. Efficiency and Layout of Simple and Complicated Planetary Drives (Wirkungsgrad und Aufbau einfacher und zusammengesetzter Umlaufraedergetriebe), H. Brandenberger. Maschinenbau (Berlin), vol. 8, nos. 8 and 9, Apr. 18 and May 2, 1929, pp. 249–253 and 290–294, 51 figs. Apr. 18: Simple method of calculating revolving speed; torques and friction losses; graphical representation and exemplification. May 2: Usefulness for transmission purposes; design efficiency.

GLIDERS

Racing, Germany. Rhoen Glider Competition. Aero Digest, vol. 14, no. 5, May 1929, pp. 64 and 252, 5 figs. Description of gliders entered in Rhoen glider competition in 1928; two-seater training gliders; conclusions reached by Kuppen in attempts to improve performance of glider by increasing aspect ratio; carefully designed glider with unusually narrow fuselage brought out by Kegel.

GRINDING MACHINES

Surface. New Lumsden Plano-Type Surface Grinding Machine. Machy. (Lond.), vol. 34, no. 867, May 23, 1929, pp. 242–243, 3 figs. Description of plano-type surface grinding machine built by Lumsden Machine Co., Gateshead; in addition to reciprocating motion of table, grinding head has transverse movement; combined motions enable comparatively small wheel to cover large surface; control allows two motions to be used separately or in varied combinations to suit work to be ground; maximum table 7 ft. 10 in.; maximum cross traverse of grinding head 2 ft. 8 in.

Revolving vs. Sliding Tables for Surface Grinding Machines With Vertical Grinding Wheel Spindle (Rundtisch oder Langtisch bei Flaechenschleifmaschinen mit senkrechter Schleifwelle?), O. L. Breidenbach. Maschinenbau (Berlin), vol. 8, no. 8, Apr. 18, 1929, pp. 254–257, 14 figs. Investigations based on practical examples; critical discussion of stress diagrams of spindle head and table drive; why preference should be given to revolving table.

H

HARDNESS TESTING

Methods. New Method in Measuring Hardness, A. F. Shore. Heat Treating and Forging, vol. 15, no. 5, May 1929, pp. 595–598, 4 figs. Study of hardness determinations; advisability of reading pressures required to produce standard impression on surface tested; first constant-size impression machine disappointment; latest theory of hardness; qualitative and quantitative analysis; steel ball vs. diamond ball Brinell numbers; virgin hardness and effect of excessive deformation; effect of diverse shaped penetrators;

measurement of qualitative and quantitative hardness; universal standard as one of mean hardness; measuring hardness of superhard materials. Abstract of paper presented before Am. Soc. Steel Treating.

The Differential Method for Measuring the Thickness of Hard Cases Without Sectioning Them, E. G. Herbert and P. Whitaker. Iron and Steel Inst.—Advance Paper no. 6, May 1929, 10 pp., 6 figs. partly on supp. plate. See also Engineering (Lond.), vol. 127, no. 3304, May 10, 1929, pp. 593–594, 4 figs. Method described consists in making two different hardness tests; primary test which measures only one variable hardness of case, and secondary test which measures combined effect of two variables, hardness and thickness of case; two hardness tests used in differential method are pendulum time test and Brinell test.

HYDRAULIC TURBINES

Draft Tubes. The Natural Flow Draft-Tube, Its Application and Merits, K. Enz. Shibaura Review (Tokyo), no. 2, Feb. 14, 1929, pp. 67–78, 14 figs. Study by Dengyosha Hydraulic Laboratory, Tokyo, comparative efficiency tests of elbow tube and natural-flow tube showing maximum efficiency of 88 per cent.

High-Head. Recent Installations of Francis Turbines for High Heads (Quelques installations hydroelectriques récentes avec turbines Francis pour hautes chutes). Technique Moderne (Paris), vol. 21, no. 6, Mar. 15, 1929, pp. 183–185, 6 figs. Illustrated description of station of Steyrische Wasserkraft und Elektrizitaets A.G. of Gratz, Austria; with spiral Francis turbines, some 15,000 hp. could be developed by three units under head corresponding with vertical distance between floor of machinery and level of upstream reach; installation called for special precautions on account of considerable axial thrust applied to turbine. Translated into French from V.D.I. Zeit., Apr. 1928.

Maintenance and Repair. Care and Maintenance of Hydraulic Turbines. Power Plant Eng., vol. 33, no. 11, June 1, 1929, pp. 656–659, 5 figs. Inspection should determine condition of runners, gate mechanisms, governor, and accessories and proper adjustments and repairs must be made; typical inspection reports; analysis of causes of outage of hydraulic-turbine generators.

Propeller-Type. Kaplan and Propeller Turbines (Les turbines Kaplan et les turbines à hélice). Génie Civil (Paris), vol. 94, no. 19, May 11, 1929, pp. 453–456, 13 figs. Comparative study of characteristics of Kaplan and Francis turbines; construction features of Kaplan turbines, their regulation and operation in practice.

Reports of the Model Tests of the Propeller Type Water Turbines, B. Tanaka. Soc. Mech. Engrs. of Japan—Jl. (Tokyo), vol. 32, no. 142, Feb. 1929, pp. 92–103. Testing plant for water turbines was installed in 1926 by Hitachi Engineering Works at Kameido Works, Tokyo; paper is first report of model tests of propeller-type turbines made in this plant during last two years; after 14 model tests, one having 4 blades with special airfoil, showing 84.5 per cent efficiency at specific speed of 150 in English units, was chosen as typical. (In Japanese.)

I

INDUSTRIAL MANAGEMENT

Belgium. Scientific Organization of Work and Rationalization (L'organisation scientifique du travail et la Rationalisation). P. Haidant. Revue Universelle des Mines (Liége), vol. 1, no. 5, Mar. 1, 1929, pp. 131–137. Reference is made to work of Amar entitled, The Human Motor; Belgium's role in study of problems of human work; rationalization is here defined as application to industrial work of maximum efficiency with minimum effort; industrial and economic reorganization, and financial rationalization in Belgium are discussed.

Cost Accounting. Operating Cost Standards, C. J. Robinson. Soc. Indus. Engrs.—Bul., vol. 11, no. 4, Apr. 1929, pp. 3–10. It is claimed that average plant is normally operated on small margin of net profit, so small that little as 4 or 5 per cent reduction in operating costs may double net profits, or 5 per cent increase may transfer operations to red side of ledger; with narrowing spread between gross sales and gross expenses, it behooves every plant to turn again to sort of leadership which shows how to get more out of dollar; standard practice instruction; weekly efficiency statement; yardstick of operation is described.

Punched-Card Method and Accompanying Calculations for the Electrical Industry (Lochkartenverfahren und mitlaufende Kalkulation in der elektrotechnischen Industrie), J. H. Schulz. Technik u. Wirtschaft (Berlin), vol. 22, no. 2, Feb. 1929, pp. 41–45, 3 figs. Practice of Siemens-Schuckert plant illustrated by means of standard forms and diagrams.

Industrial Engineers. Industrial Diagnosticians, W. N. Polakov. Am. Mgmt. Assn.—Production Executives' Series, no. 17, 1929, 23 pp., including discussion. Discussion of relations between consulting specialists managerial technique and industrial executive; place of specialist in modern industry; tactics and technique to be employed under such relations.

Labor Turnover. Measuring and Reducing Labor Turnover, J. J. Berliner. Paper Industry, vol. 11, no. 2, May 1929, pp. 237–240. Labor turnover defined as mobility existing in working force of organization; several methods of computing turnover are cited and formulas are given; causes and costs of labor turnover.

Lot Sizes. The Best Lot Size—Mathematical Formulas in Determining Production Policies, C. N. Neklutin. Factory and Indus. Mgmt., vol. 77, no. 6, June 1929, pp. 1221–1224, 3 figs. Point of balance between decrease in set-up costs by manufacturing in large lots, and increase in interest and other charges involved in carrying these lots in stock until sold; author develops formulas which permit of precise determination of this point of balance, or most economical size of lot; use in representative test cases may save considerable money by indicating wrong production policies.

Stores Control. Principles of Materials Control, H. H. Flagg. Iron Age, vol. 123, no. 19, May 9, 1929, pp. 1275–1277. Forecasts based on performance and schedule need frequent revision; effect of engineering changes; forecasts three months in advance; keeping track of stock; necessity for monthly revisions; effect of changes and irregularities; lack of coordination frequent; confusion regarding parts numbers; when old number is continued. Paper presented before Am. Soc. Mech. Engrs.

INDUSTRIAL PLANTS

Inspection. Outline of a System of Inspection, W. Hutchinson. Heat Treating and Forging, vol. 15, no. 5, May 1929, pp. 573–575. Step-by-step inspection properly organized eliminates defective material and parts before additional labor is spent on them; plan outlined fits needs of average shop; defects not found on first inspection entail added loss; all rejected material falls under one of two heads; duplicate halves of tags aid in accounting.

INTERNAL-COMBUSTION ENGINES

Atkinson Cycle. Possibilities of Atkinson Cycle Applied to Engines of Normal Maximum Pressure, S. J. Ellis. World Power (Lond.), vol. 11, no. 65, May 1929, pp. 474–476, 6 figs. Revival of machine produced by Atkinson in 1886 with four strokes of different lengths; explanation of principle with reference to inherent possibilities with regard to increased thermal efficiency.

Induction Systems. Effect of Intake Pipe on the Volumetric Efficiency of an Internal-Combustion Engine (Einfluss der Laenge der Saugleitung bei Verbrennungsmotoren), A. Capetti. V.D.I. Zeit. (Berlin), vol. 73, no. 19, May 11, 1929, p. 650. Article previously indexed from Nat. Advisory Committee for Aeronautics—Tech. Memorandums, Feb. 1929, translated from Annalli della R. Scuola d'Ingegneria di Padova, Dec. 1927.

Lubrication. Physical Principles of Lubrication, in Particular for Explosion Engines (Untersuchungen ueber die physikalischen Grundlagen des Schmierungsvorganges, insbesondere im Explosionsmotor), S. Kyropoulos. Zeit. fuer Technische Physik (Leipzig), no. 1, 1929, pp. 2–19, 5 figs. See also translated abstract in Chem. Abstracts, vol. 23, p. 1746. Basic principle of lubrication; besides thermal condition of engine oil combustion, etc., electric condition is of importance; viscosity curves of 30 different oils between 20 and 150 deg. were determined; best temperature is obtained with medium viscosity.

Supercharging. The Supercharging of Internal Combustion Engines (La suralimentation des moteurs à combustion interne), C. Waselge. Technique Aéronautique (Paris), vol. 20, no. 88, Feb. 15, 1929, pp. 22–40, 28 figs. Applications of superchargers to automobile and airplane engines; design of Cozette, Roots, Powerplus, Zoller and M. Z. volumetric superchargers; those employed on automobiles generally volumetric, but for airplane engines, centrifugal superchargers are most advantageous; history of development of supercharger by Rateau; results obtained with Rateau supercharger attached to Renault engine in Breguet plane and with other French, English, German, and American engines.

[See also AIRPLANE ENGINES; AUTOMOBILE ENGINES; DIESEL ENGINES; GAS ENGINES; OIL ENGINES.]

K

KEYS AND KEYWAYS

Standardization. The Standardization of Keys and Keyways, W. Reavell. Engineering (Lond.), vol. 127, no. 3302, Apr. 26, 1929, pp. 529–531 and (discussion) 523–524, 6 figs. Work of Subcommittee of Engineering Standards Committee, now British Engineering Standards Association, in last 24 years is outlined; results of experiments by Ransome and National Physical Laboratory; gib-headed keys; pig-feather keys; coned keys and keyways; splines; four and six splines; multiple splines; serrations; taper pins; standard nomenclature; testing machines illustrated. Paper read before Inst. Mech. Engrs.

KINEMATICS

Straight-Line Motion, New. A New Straight-Line Motion, P. Cormac. Engineering (Lond.), vol. 127, no. 3307, May 31, 1929, p. 663, 2 figs. Results of tests to ascertain whether idle wheel could be introduced between two elliptical wheels, and eccentricities of ellipses so adjusted that motion transmitted by train would be same, except as regards direction, as if two elliptical wheels meshed directly; replacement of elliptical gear pairs by their equivalent crossed quadrilater would give link mechanism which would cause two shafts to rotate in opposite directions with equal speeds; particular interest of problem lay in this, and in fact that such linkage would give almost directly new straight-line motion.

L

LAPPING

Lapping Machines, Crankshaft. Crankshaft Lapping Machines. Machy. (Lond.), vol. 34, no. 865, May 9, 1929, pp. 184–185, 4 figs. Description of crankshaft lapping machine developed by Star Motor Co., Wolverhampton, for lapping journal and crankpin bearings of 6-cylinder crankshafts; these are designed with seven journal bearings, feature of machines being that it is arranged in such manner that all journal bearings and all crankpins are lapped simultaneously on two similar crankshafts.

LIFTING MAGNETS

Railway Material. Lifting Magnets for Handling Railway Material. Locomotive (Lond.), vol. 35, no. 441, May 15, 1929, pp. 167–168, 2 figs. For dealing with material of varying shapes and sizes circular magnet gives better service; rectangular magnet is similar in design and construction except that it is not made to stand extremely rough wear for which circular magnet is especially designed; both may be employed either on locomotive crane, traveling crane, or other type.

LOCOMOTIVES

Diesel. Power and Tractive Power Curves of Diesel Locomotives (Leistungs und Zugkraftkurven der Diesellokomotive), Mangold. V.D.I. Zeit. (Berlin), vol. 73, no. 21, May 25, 1929, pp. 729–732, 6 figs. Direct and indirect power transmission and determination of maximum efficiency at given weight and transmission system.

Electric. New Electric Locomotives of German Government Railroads (Neuere elektrische Lokomotiven der Deutschen Reichsbahn), Tetzlaff and Schlemmer. V.D.I. Zeit. (Berlin), vol. 73, no. 20, May 18, 1929, pp. 667–676, 35 figs. partly on supp. plates. Four typical electric engines in operation are discussed; heavy and light freight locomotives type 1 Co plus Co 1 and 1BB1, and express locomotives of 1D01 type are detailed.

Progress in Design of Electric Locomotives (Fortschritte im Bau elektrischer Lokomotiven), K. Sachs. V.D.I. Zeit. (Berlin), vol. 73, no. 20, May 18, 1929, pp. 677–695, 68 figs. Description of locomotive drives and running gear since World War; investigation of their practicability on basis of experience; single-axle drives of Klunow, Buchli, and quill drive and gears of Kraus-Helmholtz truck type are specially treated

as being most promising; traction motors for three and one-phase current and d.c. design of vertical motors.

Fireboxes. Locomotive Firebox Conditions: Gas Compositions and Temperatures Close to Copper Plates, T. M. Herbert. Instn. Mech. Engrs.—Proc. (Lond.), no. 4, 1928, pp. 985–1006, 8 figs. Tests were carried out in connection with actual sampling of firebox gases; while further runs were made with different types of engines to estimate maximum surface temperatures attained in various parts of firebox during working of locomotives; stayhead temperatures are recorded and are somewhat lower than had been anticipated; they vary rather seriously in different parts of same firebox, usually reaching maxima under brick arch; temperatures are appreciably influenced by work which engine performs and by amount of scale on water side of plates.

Gasoline-Electric. Material Handling Using Gasoline Locomotives, G. D. Whitcomb. Iron and Steel Engr., vol. 6, no. 5, May 1929, pp. 197–200, 2 figs. Advantages and operation costs of gasoline-electric locomotives, especially industrial ones; comparison between efficiency of gasoline engine, engine fitted with fuelizer, engine fitted with gasifier, and Diesel engine; importance of fuel consumption; comparison with steam locomotive; relative costs of various machines.

Oil-Electric. Westinghouse Builds 300-hp. Oil Locomotive, D. G. Herschberger and R. O. Nash. Ry. Elec. Engr., vol. 20, no. 5, May 1929, pp. 154–157, 6 figs. Locomotive weighs 111,000 lb. and with adhesion factor of 25 per cent develops starting tractive force of 27,750 lb.; motors can develop maximum starting tractive effort of 45,000 lb., 17,800 lb. at hourly and 8800 lb. at continuous rating; maximum speed is 30 m.p.h.; engine drives variable-voltage generator; cab structure extensively welded; locomotive performance curve.

Pocono Type. Pocono Type Locomotive for Freight Service. Ry. Jl., vol. 35, no. 5, May 1929, pp. 18–19, 2 figs. High-speed freight locomotives are 4–8–4 type; cylinders have 28-in. diam. by 32-in. stroke; driving wheels 70-in. diam.; boilers operate under 235 lb. pressure; fuel is soft coal; maximum tractive power 71,600 lb.; capable of moving train of total weight of 5,000,000 lb. at rate of 50 m.p.h. on level.

M

MACHINE DESIGN

Stresses of Curved Members. Contact Pressures and Stresses of Curved Members, E. G. Coker. Inst. Mechanical Engrs.—Proc. (Lond.), no. 4, 1928, pp. 901–920, 11 figs. A few simple cases are examined; photoelastic measurements of stress in roller; uniform normal load over whole of curved surface of disk; contact pressure and stress distribution at a pin pressed against hole in plate.

MACHINE TOOLS

Depreciation. Proper Machine Tool Depreciation Rate Is Important Factor, J. T. Otto. Iron Trade Rev., vol. 84, no. 21, May 23, 1929, pp. 1400–1401. Deterioration, wear and tear, obsolescence, and inadequacy necessitate allowance for replacement of equipment; application of depreciation to costs is discussed; depreciation and burden rates on plant eqnipment must be calculated on current price values and not on cost of acquisition if provision is to be made for replacement of assets. Abstract of paper presented before Nat. Assn. Cost Accountants.

MATERIALS HANDLING

See AUTOMOBILE PLANTS; FOUNDRIES; SHEET-METAL WORKING.

METALS

Cold-Working. Texture of Cold-Worked Metals (Texturen kaltverformter Metalle), W. E. Schmid. Zeit. fuer Technische Physik (Berlin), vol. 10, no. 4, pp. 141–143, 5 figs. Close relationship of texture of copper, aluminum, and iron after deformation processes, such as stretching, compressing, and rolling are pointed out.

Ductility, Testing. Proposed New Criteria of Ductility From New Law Connecting Percentage Elongation With Size of Test-Piece, D. A. Oliver. Instn. Mech. Engrs.—Proc. (Lond.), no. 4, 1928, pp. 827–850 and (discussion) 850–864, 9 figs. Description of testing methods and results which indicate that percentage elongation obtained in test is function of original gage length and cross section area; critical examination and analysis of previous investigation.

Machinability. Cutting Tools Research Committee—Report on Machinability, E. G. Herbert. Instn. Mech. Engrs.—Proc. (Lond.), no. 4, 1928, pp. 775–801 and (discussion) 802–825, 39 figs. Investigation limited to machinability of sharp cutting tool used in bar lathe; review of results of private investigations; apparatus provided for test and specifications of test bars used; effect of speed on chip formation; measurement of machinability by hardness of chip; conclusions resulting from investigations are given. Previously indexed from several sources.

Proportional Limit. The Determination and Significance of the Proportional Limit in the Testing of Metals, R. L. Templin. Am. Soc. Testing Matls.—Preprint, no. 90, for mtg. June 24–28, 1929, 12 pp., 6 figs. Discussion of factors affecting proportion limit; attempts to give idea of quantitative effects of various factors on proportional limit; numerous stress-strain diagrams for series of tension test specimens $\frac{1}{2}$ in. in diam. all prepared from same material, but tested under different conditions, are given; it appears that so-called yield point is appreciably easier to determine on routine commercial testing basis than proportional limit and probably is adequate for needs of designer and for product specification purposes.

Temperature Effects. Special Metals Required for Extreme Temperatures and Pressures, A. E. White and C. L. Clark. Power, vol. 69, no. 22, May 28, 1929, pp. 898–899, 4 figs. Metals to be used for temperature from 700 to 900 deg. and over; ferrous and non-ferrous divisions and group, including plating with metals, as chromium, nickel, etc., and nitriding; curves showing properties of 0.13 per cent carbon steel at high temperature; expansion results, safe working loads and proportioned limit values for 38 per cent carbon-steel tubing; flow tests on chromium-tungsten steel at 1000 deg. fahr. with various selected steels.

MODELS

Mechanical Engineering, Research With. Research in Mechanical Engineering by Small-Scale Apparatus, F. C. Johansen. Engineering (Lond.), vol. 127, nos. 3300 and 3303, April 12, May 3 and 24, 1929, pp. 469–470, 567–568, and 655–658, 4 figs. Apr. 12: Vibration and strength of structures; flutter of airplanes. May 3: Redundant frames; tests on hexagonal framework representative of rigid airship frame; reduced elasticity models; scale-model research for heat transmission; scale effects in forced convection from cylinders. May 24: Surface roughness; hydraulics and ventilation.

IRON FOUNDING

Molding Practice. Some Interesting Moulding Jobs, E. Longden. Foundry Trade Jl. (Lond.), vol. 40, nos. 661 and 662, Apr. 18 and 25, 1929, pp. 283–284 and 301–304, 18 figs., and (discussion) no. 663, May 2, 1929, p. 322. Apr. 18: Making molds for large centrifugal pump body; requirements to produce casting; molding bottom part of pump; core-making details. Apr. 25: Molding top portion of pump; casting pulping-machine jacketed cylinder; making pattern and cores; molding details; carding-engine cylinder castings; pattern-making details; molding-box construction; construction of core barrel. May 2: Discussion of paper.

N

NON-FERROUS METALS

Fatigue Studies. Fatigue Studies of Non-Ferrous Sheet Metals, J. R. Townsend and C. H. Greenall. Am. Soc. Testing Matls.—Advance Paper for mtg. June 24–28, 1929, no. 44, 12 pp., 12 figs. Paper describes development of fatigue test machine for sheet metals and gives results of fatigue tests on five alloys of alpha-brass, one alloy of nickel-silver, one alloy of phosphor-bronze, and Everdur; results indicate that cold work raises endurance limit but not proportionally to increase in tensile strength produced by same cause; micrographs are shown indicating that fatigue failure of metals investigated is transcrystalline.

Testing. Physical Properties and Methods of Test of Some Sheet Non-Ferrous Metals, J. R. Townsend, W. A. Straw and C. H. Davis. Am. Soc. Testing Matls.—Preprint for mtg. June 24–28, 1929, no. 46, 36 pp., 20 figs. Continuation of investigation undertaken to secure simple and reliable method test and development of commercial test limits; Rockwell hardness of tensile-strength limits are given for four alloys of brass, and two alloys each of nickel-silver and phosphor-bronze; grain size limits are given for annealed brass, nickel-silver, and phosphor-bronze sheet; refinements in calibration of Rockwell tester by sheet; refinements in calibration of Rockwell tester by using standard test blocks are given.

O

OIL ENGINES

Cylinder Temperatures. Cylinder Temperatures in 25 B.H.P. Crude-Oil Engine, and Their Effect on Engine Performance, F. R. B. Watson. Instn. Mech. Engrs.—Proc. (Lond.), no. 4, 1928, pp. 935–952, 5 figs. Results of experiments carried out on hot-bulb engine to determine throughout whole range of loads and with same setting of fuel-injection cam, temperature of hottest parts in cylinder, piston friction, and data for a heat balance; from results it can be seen that when temperature conditions in cylinder begin to approach abnormal state, quantities on which power depends begin to change more rapidly.

P

PUMPS

Feedwater, Design of. Meeting Hydraulic and Mechanical Requirements in Boiler Feed Pump Design, O. H. Dorer. Power, vol. 69, no. 22, May 28, 1929, pp. 876–877, 2 figs. Present experiences resulting from upward development of pressure in steam power point forcibly to conflict between mechanical requirements and desirable hydraulic features.

PUMPS, CENTRIFUGAL

German Water Works. Steam - Turbine Pumps of the Berlin Water Works (Dampfturbopumpen in der Wasserversorgung der Stadt Berlin), B. Rosenfeld. Gas u. Wasserfach (Munich), vol. 72, no. 13, Mar. 30, 1929, pp. 295–299, 9 figs. Features of steam-turbine pumps of Tegel, Stolpe, and other pumping stations, ranging from 370 to 1055 hp., pressure from 14 to 22 atmos. steam at 350 deg. cent., head 32 to 90 m., discharge 2000 to 5000 cu. m. per hr.; turbine speed 3400 to 7850 r.p.m.; pump speed 590 to 780 r.p.m.

High-Pressure. High-Pressure Centrifugal Pumps for Large Lifts, G. Weyland. Eng. Progress (Berlin), vol. 10, no. , May 1929, pp. 118–121, 8 figs. Development of centrifugal pumps for large heads; example of maximum combination of lift, output, and pump speed; nine-stage centrifugal pumps for 7500-ft. lift; limits to centrifugal-pump design.

Performance Curves. How to Apply Performance Curves to Pump Installations, M. J. Reed. Power, vol. 69, no. 20, May 14, 1929, pp. 788–791, 6 figs. Performance curves for selecting proper size of centrifugal pumps; curves showing effect of change in pump speed; method of finding flow in branch lines; combined head capacity for pump operating in series of parallel; effect of throttling discharge and of pressure regulator on pump speed and horsepower.

Priming. Self-Priming Device for Centrifugal Pumps (Auto-amorceur pour pompes centrifuges). Génie Civil (Paris), vol. 94, no. 21, May 25, 1929, p. 506, 2 figs. Details of device consisting of spherical tank, with conical tube inside of it, inserted in bent suction main little above pump, manufactured by Ateliers de Constructions Electriques de Charleroi. From Revue A.C.E.C., Oct.-Dec. 1928.

PUNCHING MACHINES

Angle. Triple-Head Angle Punching and Cropping Machine. Engineer (Lond.), vol. 147, no. 3828, May 24, 1929, p. 582, 2 figs. Details of machine made by James Bennie and Sons, to facilitate mass production of steel transmission towers required for various "grid" schemes now being carried out.

R

RAILWAY MOTOR CARS

Operating Conditions. Engine - Operating Conditions on Rail Cars With Electric Drive Termed Almost Ideal for Service, C. O. Guern-

sey. Automotive Industries, vol. 60, no. 20, May 18, 1929, pp. 758–761, 3 figs. Rail-car operating conditions are discussed; rail cars used to advantage in seven classes of service; power plant designed for long life, many being operated as far as 120,000 mi. between overhaul periods; electric-drive usage; remote control favored; utilization of power; fuel consumption; ideal load line; accessory devices. Abstract of paper presented before Soc. Automotive Engrs.

REFRIGERATING MACHINERY

Compressors, Centrifugal. Process for Calculation of Centrifugal Compressors and Its Application to Refrigerating Machines (Ein Verfahren zur Berechnung von Kreiselverdichtern und seine Anwendung auf Kaeltemaschinen), C. Colombi. Zeit. fuer die Gesamte Kaelte-Industrie (Berlin), vol. 36, nos. 3, 4, and 5, Mar., Apr. and May 1929, pp. 48–51, 68–72 and 87–92, 18 figs. Mar.: Design and operation of single-stage compressor. Apr.: Efficiency and characteristics of single- and multiple-stage compressors; diagram showing speed characteristics; trigonometric transformation of derived equations. May: Numerical applications and corresponding graphic models.

Design. Calculation of Refrigerating Machines (Le calcul des machines frigorifiques), G. Bricard. Revue Industrielle (Paris), vol. 59, no. 2236, Mar. 1929, pp. 144–149, 9 figs. Notes on application of entropy diagram to calculation of refrigerating machines; reproduction of entropy diagram for carbon dioxide and of curves for constant pressure and refrigerating cycles; of modern refrigerating machine.

REFRIGERATION

Evaporating Systems. Recent Developments in Evaporating Systems, T. Shipley. Refrig. World, vol. 64, no. 5, May 1929, pp. 23–25. Effect of design upon operation of coil in evaporator; results of change in mean temperature difference; change of load and its effect upon liquid content of coil; float control is safeguard against flushovers and also makes it possible to fill coil with sufficient liquid to keep inner evaporating surface wet continually during period of maximum demand; automatic expansion valve and thermostat control considered unsatisfactory.

ROLLING MILLS

Cold-Rolling, Power for. Roll Pressure and Rolling Work in the Cold Rolling of Metals (Walzdruck und Walzarbeit beim Kaltwalzen von Metallen), E. Siebel and A. Pomp. Mitteilungen aus dem Kaiser-Wilhelm-Institut fuer Eisenforschung (Duesseldorf), vol. 11, no. 4, 1929, pp. 73–85, 14 figs. Cold rolling tests on bands of mild and hard steel and of copper showed that only 10 to 40 per cent of energy supplied by mill motor was employed in changing shape of material; deformation efficiency of cold-rolling to roll diameter, with increasing reduction of draft, and with increasing friction between rolls and material.

Reconstruction. Reconstruction of Rolling Mills (Der Umbau von Walzwerken), J. Schubert. Stahl u. Eisen (Duesseldorf), vol. 49, no. 20, May 16, 1929, pp. 734–737, 7 figs. Notes on reconstruction of reversing blooming mill, and other types of rolling mills; installation of new parts and time required for such installations.

S

SAND, FOUNDRY

Testing. Testing of Foundry Sands in Theory and Practice (Formsandpruefungen in Theorie und Praxis), F. Roll. Giesserei (Duesseldorf), vol. 16, no. 17, Apr. 26, 1929, pp. 393–401, 26 figs. Relations between gas permeability, strength, sedimentation, adsorption, etc., are discussed; brief notes on burden, followed by detailed discussion of works testing.

SHEET-METAL WORKING

Materials Handling. Materials Handling for Sheet Metals, J. Carmody and G. E. Hagemann. Iron Age, vol. 123, no. 23, June 6, 1929, pp. 1565–1566. Survey of question of management layout and materials-handling in manufacturing processes; inertia hampering progress; operation of sheet-metal shop; supplies for at least 4 hr. of work; scrap difficult to handle; paper wrapping of sheets; automobile body building. Abstracts of two papers presented before Am. Soc. Mech. Engrs.

SPRINGS

Laminated. Kinematics of Laminated Springs, H. S. Rowell. Engineering (Lond.), vol. 127, no. 3302, Apr. 26, 1929, pp. 505–507, 9 figs. Advantages of laminated springs over other types and their application to automobiles; motions in quarter-elliptic and semi-elliptic springs calculated; shackle problems in latter discussed; relative rotation between spring eye and shackle; efforts of shackle position and slope on spring stress and general behavior; cantilever springs.

Laminated Springs, R. G. Batson and J. Bradley. Times Trade and Eng. Supp. (Lond.), vol. 24, no. 566, May 11, 1929, p. 210. Review of special report no. 13 of Springs Research Committee of Department of Scientific and Industrial Research; static and endurance tests on laminated springs made of carbon and alloy steels suggest that explanation of unexpected fractures now found in practice may lie in effect due to skin on leaves of springs.

Steel for. Selection of Steel for Springs. Iron Age, vol. 123, no. 21, May 23, 1929, p. 1416. Results of study made at British National Physical Laboratory reported to Iron and Steel Institute; table shows physical properties of quenched and tempered spring steels.

Testing Machines. New Spring Endurance Tester Operates on Single Leaf, J. Bradley. Automotive Industries, vol. 60, no. 22, June 1, 1929, pp. 842–843, 1 fig. Description of new endurance-testing machine for leaf-spring material developed in England in connection with work of Springs Research Committee of Department of Scientific and Industrial Research; using 1-hp. high-speed motor machine, gives data on approximating Wohler test; vibration trouble eliminated. From Engineering, Jan. 11, 1929.

STEAM

Callendar Steam Tables. Extended Steam Tables, H. L. Callendar. Engineering (Lond.), vol. 127, nos. 3303 and 3304, May 3 and 10, 1929, pp. 546–547, 1 fig., and editorial comment 553–554. See also Engineer (Lond.), vol. 147, no. 3825, May 3, pp. 484–485 and editorial, p. 492. With assistance of British Electrical and Allied Industries Research Association, it became possible to make direct measurements of total heat of water and steam at pressures up to 4000 lb. per sq. in., and temperatures up to 750 deg. fahr.; calculation of numerical values for two constants from observed values of H and V at critical point; methods of taking and reducing observations; effect of air and other impurities in steam.

High-Pressure. High-Pressure Steam; Its Production and Use (La vapeur d'eau à haute pression: sa production, son emploi), L. Gendron. Pratique des Industries Mécaniques (Paris), vol. 12, no. 1, Apr. 1929, pp. 1–9, 12 figs. Engineering formulas and properties of high-pressure steam; Babcock and Wilcox, Brown Boveri, and Atmos equipment described.

Properties. Heat of Vaporization of Water and the Specific Volume of Saturated Steam Between 210 and 250 Degrees Centigrade (Die Verdampfungswaerme des Wassers und das spezifische Volumen von Sattdampfzwischen 210 and 250 deg. cent.), M. Jakob and W. Fritz. V.D.I. Zeit. (Berlin), vol. 73, no. 19, May 11, 1929, pp. 629–636, 6 figs. Report from German Government Institute of Engineering Physics on methods, apparatus used, and results obtained; temperatures were measured with platinum resistance thermometer.

STEAM CONDENSERS

Design. Surface and Mixing Condensers (A L'étude des condenseurs à surface et des condenseurs par mélange), R. Vrinat. Arts et Métiers (Paris), vol. 82, no. 102, Mar. 1929, pp. 81–87, 4 figs. General principles, calculation, and design of both systems.

Surface. The M. V. Central Flow Surface Condenser, C. G. Lloyd. Metropolitan-Vickers Gaz. (Manchester), vol. 11, no. 192, Mar. 1929, pp. 222–224, 3 figs. Central flow type of Metropolitan Vickers Co.; principle; influence of pressure drop on conductivity; temperature of condensate; de-aeration of condensate; effect of pressure drop on air pump performance; advantages.

STEAM-ELECTRIC POWER PLANTS

France. The Ivry Port Power Station, Paris. Engineering (Lond.), vol. 127, nos. 3304 and 3305, May 10 and 17, 1929, pp. 569–572 and 603–606, 14 figs. partly on p. 584 and supp. plate. May 10: Details of station on Seine River, primary object of which is to supply power to Metropolitan Underground Railway; installed capacity is 60,000 kw.; turbine units develop 12,000 kw.; coal and ash handling; power-house equipment, turbine house, etc. May 17: Details of main turbo-generator units, condensers, deaerators, extraction pump, high-tension switchgear, etc.

Fuel Economy. Fuel Control in Electric Power Stations, F. Munzinger. Engineering (Lond.), vol. 127, no. 3307, May 31, 1929, pp. 705–708, 4 figs. Advantages of high steam pressures only become apparent when extracted steam is used for heating of feedwater; reheating of feedwater by extracted steam; special preheat turbines are being used in Klingenberg station at Berlin, output of which is 10,000 kw. at 3000 r.p.m.; author prefers reheating by live steam, rather than by flue gases, reasons for which are explained. Paper read before Inst. of Fuel.

Holland, N. J. Design of Holland Station. Power, vol. 69, no. 22, May 28, 1929, pp. 859–862, 3 figs. Design of 1400-lb. station at Holland, N. J.; ultimate capacity, 220,000 kw. in 1930; at present 55,000 cross-compound turbine with 11,800 kw. high-pressure and 43,200 low-pressure elements are installed; diagrams of arrangement of heating service and steam distribution between boilers and turbines are given.

New York City. Features of New 320,000-Kw. Extension at Hell Gate. Power Plant Eng., vol. 33, no. 11, June 1, 1929, pp. 606–613 and 648–651, 14 figs. Developments since 1921 to latest extension with two 160,000-kw. Brown Boveri turbine-generators and additional boiler equipment; details of three pulverized-coal-fired boilers; plan of station and cross-section of new boilers; control gear for turbine; 88,200-kw. generator driven by high-pressure element of Brown Boveri turbine; Westinghouse 165,000-kw. unit; tabulation of data on 1928 installation.

Latest 165,000-Kw. Unit Gives Hell Gate 600,000 Kw. Elec. World, vol. 93, no. 22, June 1, 1929, pp. 1089–1090, 3 figs. Hell Gate station of United Electric Light and Power Co. of New York attained position of world's largest power plant by placing in service two-cylinder cross-compound turbo-generator unit; high-pressure turbine at 1800 r.p.m. drives 94,200-kva., 13,800-volt generator directly connected to two 200-kw., 250-volt main generator exciters; low-pressure turbine drives another 94,200-kva. generator and 6250-kva., 2400-volt house-current generator and 50-kw. auxiliary generator exciter.

The Hudson Avenue Power Station, New York. Engineering (Lond.), vol. 127, no. 3303, May 3, 1929, pp. 547–550, 4 figs. Power plant of Brooklyn Edison Co., containing five 110,000-kw., 13,800-volt, three-phase, 62.5-cycle at 1200 and 1800 r.p.m. and 700 deg.; boiler and engine room equipment described; heat balance and power diagram for fan and inlet valve control.

STEAM PIPE LINES

Heat Transmission Through. Heat Transmission Through Long-Distance Steam Pipe Lines (Waermeuebertragung durch Ferndampfleitungen), E. Vogel. Waerme (Berlin), vol. 52, no. 17, Apr. 27, 1929, pp. 362–364, 3 figs. Development of mathematical relations for heat and pressure losses in long-distance steam lines; it is shown that saturated as compared with superheated steam has always less heat and pressure losses in pipe lines; example is given indicating when use of saturated or superheated steam is more expedient; influence of length of line and quantity of steam transmitted on thermal economy.

STEAM POWER PLANTS

High-Pressure. Operating Experience With High Pressures, I. E. Moultrop, M. K. Drewry and J. C. Segeler. Power, vol. 69, no. 22, May 28, 1929, pp. 894–897, 3 figs. Symposium of articles, giving experience data of high-pressure steam operation: at 1200-lb. Edgar Station of Edison Electric Illuminating Co. of Boston; at Lakeside plant, Milwaukee, with 1300-lb. equipment, and at Masonite Corp., Laurel, Miss., with 1000 lb.

Power and Process. P. and F. Corbin Plant Reports Operating Data for 1928. Power, vol. 69, no. 23, June 4, 1929, pp. 924–926, 5 figs. Cost and production figures for power plant of Corbin Division of American Hardware Corp., New Britain, Conn.; plant went into operation in 1924; supplies power and steam for heating and process; tabulation of equipment; operating data regarding distribution of steam and power; boiler-room and turbine-room expense; combined cost of all power services; charges against power generation and computation of boiler efficiency.

Pulverized-Coal-Fired. Pulverised Fuel Installation at the Wallasey Generating Station. Engineering (Lond.), vol. 127, no. 3302, Apr. 26, 1929, pp. 511–513, 22 figs. partly on p. 520 and supp. sheet. Details of two 50,000-lb. boilers equipped with pulverized-fuel firing on unit system; these form part of latest extensions to plant, remainder consisting of 12,500-kw. English Electric turbo-alternator with usual auxiliary apparatus; pulverizers are of Simon-Carves horizontal swinging-hammer type; boilers are

of tridrum, semi-vertical water-tube type with large solid forged mud drum.

STEAM TURBINES

Back-Pressure. Steam-Consumption Measurement of Back-Pressure and Bleeder Turbines (Beitrag zur Dampfverbrauchmessung an Gegendruck und Anapfturbinen), E. Josse. Archiv fuer Waermewirtschaft (Berlin), vol. 10, no. 5, May 1929, pp. 169–173, 14 figs. Results of new experiments with measuring nozzles; tests at varying pressures and varying steam superheat in front of orifice; influence of increase of overenlarged nozzles on permissible maximum backpressure; results of 21 tests are compiled and presented graphically.

Design. Graphic Calculation of Extraction and Mixed Turbines (Le calcul graphique des turbines à soutirage et des turbines mixtes), P. Chambadal. Technique Moderne (Paris) vol. 21, no. 10, May 15, 1929, pp. 302–308, 12 figs. Single, duplex, and triple-extraction and mixed turbines are discussed.

The Influence of Experience on the Design of the Steam Turbine, E. L. Robinson. Gen. Elec. Rev., vol. 32, no. 6, June 1929, pp. 314–317, 9 figs. Steam turbine as developed by General Electric Co. has grown from 5000 kw. of individual unit in 1903 to 208,000 kw. in triple-cross-compound unit in 1928; during this period company has manufactured steam turbines with total capacity of 20,000,000 kw.; development since 1903 is illustrated.

High-Pressure. Turbines for High Pressure and Temperatures From an Operating Point of View, B. Houghton. Power, vol. 69, no. 22, May 28, 1929, pp. 880–884, 8 figs. Review of development, and present design and performance of high-pressure, high-temperature turbines; materials for high and for low working stresses; causes of blade failures; photomicrograph of manganese-copper and phosphor-bronze turbine blades, showing intercrystalline weakness due to dissociated steam; distortion of 50,000-kw. turbine casing; hydrogen in steam; vibration and embrittlement; constant steam pressure important.

High-Temperature. 1000-Degree Turbine for Delray No. 3, J. W. Parker. Power, vol. 69, no. 22, May 28, 1929, pp. 909–910, 2 figs. Experimental installation by Detroit Edison Co. at Delray Power House No. 3, comprising 10,000 kw., 2-cylinder single-shaft turbine-generator made by British Thomson-Houston Co., England, to operate at 365 lb. and 1000 deg.; first attempt in United States to utilize high temperatures and improve turbine efficiency.

STEEL

Automobile, Machinability of. Machinability of Different Steels for the Manufacture of Automobiles (Die Bearbeitbarkeit verschiedener Baustaehle des Kraftwagenbaues), A. Wallichs and K. Krekeler. Stahl und Eisen (Duesseldorf), vol. 49, no. 22, May 30, 1929, pp. 793–799, 12 figs. Determination of machinability of certain steels according to methods developed at Aachen Machine Tool Laboratory; investigation of cutting process; results of tests; comparison of German and American automobile steels; alloy steels are less easily worked; the carbon content plays an important role in unalloyed steels.

Chromium-Nickel. See CHROMIUM-NICKEL STEEL.

Machine Parts, Heat Treatment of. Heat-treating Alloy Steel Machine Parts, C. B. Phillips. Machy. (N. Y.), vol. 35, no. 10, June 1929, pp. 773–775, 2 figs. Description of methods used in heat-treating department of Colman Co., to obtain uniform quality in varied line of machine parts; kinds of steels that have been found most serviceable; examples of heat-treatments; high-speed steel heat-treating department; equipment provided for general heat-treating department.

Spring. See SPRINGS.

Stainless. Enduro-Nirosta—A Non-Corrosive Heat-Resisting Steel That Is Workable. Am. Mach., vol. 70, no. 21, May 23, 1929, pp. 823–824, 3 figs. Outline of qualities found in new alloy steel and some of its outstanding applications; difficulties in machining largely overcome in new Enduro-Nirosta steel of the Ludlum Steel Co., Watervliet, N. Y.; heat treatment, machining, and drawing practice discussed.

Testing. Steels Are Now Available for High Pressure and Temperatures, L. W. Spring and J. J. Kanter. Power, vol. 69, no. 22, May 28, 1929, pp. 904–905, 2 figs. Long time and flow strength tests; comparison of high-temperature strength of carbon and alloy cast steels; flow-time curve of 0.33 per cent annealed carbon-cast steel tested at 800 deg. fahr. under load of 10,000 lb. per sq. in.

Tool. See TOOL STEEL.

STOKERS

Mechanical. The Invention of the Usui Patent Mechanical Stoker, B. Iwata. Soc. Mech. Engrs. of Japan—Jl. (Tokyo), vol. 32, no. 142, Feb. 1929, pp. 104–120, 9 figs. Details of stoker invented by K. Usui; number of square grate bars are placed side by side with no connection to one another; power is applied at one end of row so that bars move on from end of firebox and through it until at last they drop off one by one at other end of firebox; coal being placed on set of bars, ignition starts off gradually at top of coal and combustion proceeds toward lower part of coal. (In Japanese.)

T

TEMPERATURE SCALE

International. The International Temperature Scale. Analyst (Cambridge), vol. 54, no. 638, May 1929, pp. 292–294. In 1927, Seventh General Conference, representing 31 nations, adopted unanimously resolution approving of provisional adoption of international scale, submitted for discussion by U. S. Bureau of Standards, National Physical Laboratory, and Physikalisch-Technische Reichsanstalt; English text is given.

THERMODYNAMICS

New Heat Studies. New Studies of Heat (Nouvelles études sur la chaleur), Roszak and Vernon. Chaleur and Industrie (Paris), vol. 10, no. 108, Apr. 1929, pp. 171–176, 1 fig. Formulas for calculating mechanism of heat flow in homogeneous fluids; convection in boiling liquids; radiation in universe; diurnal heating and nocturnal cooling.

TOLERANCES

Skoda vs. D.I.N. System. The D.I.N. and the Skoda Limit Systems, G. Schlesinger. Engineering (Lond.), vol. 127, no. 3305, May 17, 1929, pp. 619–622, 8 figs. Reference is made to article by Sawin in Mar. 30, 1928, issue of same journal, in which author states that D.I.N. system of tolerances had not been found satisfactory in practice in Skoda Works, and that he had developed system of his own which was free from defects of German system; example is cited to show that Sawin's figures are not in accordance with experience gained in works of equal magnitude and standing to Skoda; comparison of bases of two systems shows that D.I.N. has systematic structure and Skoda has not.

TOOL STEEL

Hardening. Influence of Production Method and Annealing Atmosphere on Surface Texture of Tool Steel (Der Einfluss des Herstellungsverfahrens und der Gluehatmosphaere auf das Randgefuege der Werkzeugstaehle), E. Zingg, P. Oberhoffer and E. Piwowarsky. Stahl u. Eisen (Duesseldorf), vol. 49, no. 20, May 16, 1929, pp. 721–725, 13 figs. Results of tests on formation and gasification of cementite; recommends use of protective gas of two parts carbon monoxide and one part hydrogen, containing some methane and acetylene, for heat treatment of high-carbon tool steels; decarburizing and carburizing phenomena in salt baths; production of maximum hardness of hardened high-speed steel by cementation up to 580 deg. cent.

TUBES, STEEL

Manufacture. The Manufacture of Iron and Steel Tubes, J. Mitchell. West of Scotland Iron and Steel Inst.—Jl. (Glasgow), vol. 36, no. 4, Jan. 1929, pp. 48–52 and (discussion) 52–57, 9 figs. Brief description of process used in manufacture of iron and steel tubes; lines along which development may be expected; essentials in manufacture of welded tubes; process for producing butt-welded, lap-welded, hand welded, electrically, and weldless tubes; producing tubes from hollow blooms by dies, rolling, and pilgering.

Temperature Stresses. Stresses in Thick Tubes Due to Temperature, and Effects of Temperature and Pressure Stresses Acting Simultaneously, J. G. Docherty. Instn. Mechanical Engrs.—Proceedings (Lond.), no. 4, 1928, pp. 921–934, 4 figs. Method of calculation is described which may be found useful in practice; hypothesis on which equations are based and general stress equations for cylinder with radial temperature and pressure differences; stresses due to pressure differences are treated in a similar way; effects of combined temperature and pressure stresses are worked out and safe pressures for tubes with varying temperature differences or vice versa are deduced.

V

VALVES

Manufacture. Economic Manufacture of Conical Valves for Internal Combustion Engines (Wirtschaftliche Herstellung von Motorventilkegeln), H. Bauer. Maschinenbau (Berlin), vol. 8, no. 8, Apr. 18, 1929, pp. 245–249, 15 figs. Possibility of manufacturing valves on specially designed automatic machinery; two types for grinding and milling are recommended; little space is required; geared chain drive and holding device.

VIBRATIONS

High-Frequency, Recording. Recording High-Frequency Vibrations (Aufzeichnung schneller Schwingungen), H. Thoma. V.D.I. Zeit. (Berlin), vol. 73, no. 19, May 11, 1929, pp. 639–642, 15 figs. Details of high-frequency transmitter with rectifier tubes adapted for graphical recording of mechanical vibrations of power machinery and machine tools; curves obtained indicate existence of superharmonic vibrations which are of value in detecting causes of disturbances; further uses of instrument.

W

WAGES

Wage-Payment Plans. Improved Pay System for Productive Work, C. F. Scribner. Indus. Woodworking, vol. 29, no. 9, June 1929, pp. 11–13. Chief engineer of Bradner-Scribner Engineering Co., points out weakness of straight piece-rate system of paying for production labor and suggests incentive plan which is automatically adaptable to ever-changing economic conditions, including necessary revisions of wage rates.

Measuring Productive Capacity and Wage Calculation With Special Regard to Payroll Departments (Leistungserfassung und Lohnrechnung unter besonderer Berueecksichtigung des Lohnbueros), L. Rozsavoelgyi. Werkstattstechnik (Berlin), vol. 23, no. 10, May 15, 1929, pp. 285–304. Study of requirements and conditions to be met by payroll department in various types of manufacturing organizations; measures and measuring of production capacity; kinds of production capacity and registration for calculation and payment of wages; methods of calculation and arrangement of wage figures; development of gross and net wages; personnel department.

WELDING

Electric. See ELECTRIC WELDING, ARC.

WELDS

Testing. Defective Welds—Their Causes, Determination and Prevention. Present Customary Methods of Testing Welds (Fehlschweissungen und Deren Ursachen, Ihre Festellung und Verhuetung. Die derzeit ueblichen Pruefungsmethoden von Schweisstellen), J. Titscher. Mitteilungen des Staatl. Technischen Versuchsamtes (Vienna), vol. 17, no. 1–3, 1928, pp. 90–97. General discussion applying to arc welding, gas, thermit, and other types of welding.

WIND TUNNELS

Propeller-Research. N.A.C.A. 20 Ft. Propeller Research Tunnel, F. Weick and D. Wood. Aeroplane (Lond.), vol. 36, no. 17, Apr. 24, 1929, Aeronautical Eng. Supplement, pp. 656–659, 3 figs. Wind tunnel of National Advisory Committee for Aeronautics is of the open-jet type with airstream 20 ft. in diam.; jet of air is drawn through open room; tunnel particularly suitable to testing airscrews; fan belt driven by Diesel engine; test chamber 50 by 60 ft. and 55 ft. high with traveling electric crane; new type of balance developed so that full sized fuselages might be tested. Abstract of N.A.C.A. Report No. 300.

WIRE

Drawing. Power Required and the Work Done in the Cold Drawing of Wires (Ueber den Kraft- und Arbeitsbedarf beim Kaltziehen von Draehten), A. Pomp, E. Siebel and E. Houdremont. Mitteilungen aus dem Kaiser-Wilhelm-Institut fuer Eisenforschung (Duesseldorf), vol. 11, no. 4, 1929, pp. 53–72, 26 figs. Influence of material, reduction of draft, shape of die, drawing speed, and lubrication was studied; as standard of reference, efficiency of process was used; lubrication had greatest influence on efficiency; best results were obtained with composition of lime and rape oil.

IN TWO SECTIONS—SECTION TWO

MECHANICAL ENGINEERING

Published by The American Society of Mechanical Engineers, 29 W. 39th St., New York, N. Y.

Volume 51 August, 1929, Section Two Number 8

What It's All About

THE engineer must accustom himself to change because engineering is continually in a state of flux. There are times when the changes are revolutionary and come with great rapidity and affect a great portion of the profession. Some of the changes are the result of the application of an idea which has been borrowed from another field of engineering, or the practical use of a contribution of pure science.

Thus, the process of engineering education never ceases, and it is not sufficient for a man to keep in touch with his field alone. In MECHANICAL ENGINEERING there appear papers which deal with all branches of the profession. They serve to keep the mentally alert informed on progress. This supplement describes the contents of the August issue of MECHANICAL ENGINEERING. Read it and pass it on. Learn "what it's all about."

High-Speed Oil Engines

IT HAS been characteristic of oil engines that they have been heavy and slow-speed machines. Other features, such as the economy of operation, both in low fuel consumption and ability to operate on a low-priced fuel, have led designers to attempt modifying the less desirable characteristics so that engines of this type may be used for the automobile and aircraft power plant.

C. H. Gibbons summarized progress in the commercial development of high-speed oil engines at the recent national meeting of the A.S.M.E. Oil and Gas Power Division. An extended abstract of his paper appears in MECHANICAL ENGINEERING for August.

Mr. Gibbons discusses the possible application of the high-speed oil engine to aircraft, trucks, and tractors, and gives details of their application to locomotives, generating sets for city buildings, cotton ginning, oil-well drilling, pipe-line pumping, irrigation, marine propulsion, air compressors, dredges, etc. He also deals with medium-speed applications and gives data for use in estimating power costs.

Repair of Diesel Engines

ONE of the troubles that comes with the introduction of a new machine is finding skilled men to handle it and keep it in proper order. Steam engines have been used in ships for years, and all over the world can be found men who have some manner of skill in their operation and who know how to repair them when necessary. The Diesel engine introduced a new type of motive power to the marine engineer, and inexperience with its operation has been reflected in repair bills. In a paper presented before the Second National Meeting of the A.S.M.E. Oil and Gas Power Division at The Pennsylvania State College in June, Louis R. Ford gave the results of experience in the maintenance and repair of marine Diesel engines. The paper in condensed form is to be found in the August issue of MECHANICAL ENGINEERING.

Mr. Ford points out the necessity of thoroughness on the part of workmen making repairs to Diesel engines and the need for machinists with rather special qualifications. He describes the types of repairs made to bedplates, framing, cylinders and cylinder heads, crankshafts, connecting rods and crossheads, piston rods, pistons, valves and valve gear, cooling systems, and fuel pumps. Much of the work described is of interest to engineers charged with maintenance of machinery other than marine Diesel engines.

Passenger Aircraft

TOWARD the end of May the Aeronautic Division of the A.S.M.E. and the St. Louis Section held one of the largest technical meetings devoted to aeronautics ever attempted in this country. Papers from authorities in all branches of aeronautics were presented. Among those of general interest in an age which is accustoming itself to the idea of passenger air lines was one by Charles N. Monteith on "Aircraft for Passenger Transport." This paper is published in the August issue of MECHANICAL ENGINEERING.

Obviously one of the most sensible courses to pursue in teaching an earthbound people to become airminded is to make the experience of flying as pleasant as possible and to remove from it whatever psychological hazards may exist. Air-transport companies, therefore, are devoting considerable attention to the elements of comfort and safety in air travel. Mr. Monteith discusses the factors which are being studied in this connection, such as the arrangement of the cabin, safety belts and parachutes for passengers, provision for adequate lighting, opportunity for every passenger to get a good view of the country over which he is flying, heating, ventilation, control of noise and vibration, efforts to reduce air sickness and to provide for the comfort and amusement of the passengers so that they will be less likely to worry about their unusual experience.

Boiler-Metal Embrittlement

A SERIES of boiler failures in the plants of a large corporation led to an active study of the causes, and these were found to be in the nature of embrittlement. What embrittlement of boiler metal is and the conditions which cause it are set forth in a paper entitled "Recent Development in Boiler-Metal Embrittlement," by H. F. Rech, in the August issue of MECHANICAL ENGINEERING.

Sometimes spoken of as "caustic embrittlement," the mechanism of this type of failure appears to be the cracking of stressed metal in boiler drums and tubes when the feedwater is high in carbonates, with little or no

sulphates present. Microscopic examination of the affected metal shows intercrystalline cracks which are thought to be caused by the breaking up of the binder between the grains of the steel by caustic which is absorbed by the steel along the lines of stress.

Because the cracking has been found only in the stressed metal of boilers, methods of construction to avoid such stressing have been adopted. Strict attention to the character of the boiler water, however, will prevent the embrittlement of metal even when stressed.

Mr. Rech shows many examples of the failures which have occurred through embrittlement and the conditions which existed in boilers on account of improperly controlled boiler-water conditions. The experiences cited and the explanation of the causes of trouble should give all engineers responsible for boilers much valuable help.

Journal-Bearing Design

ONE of the oldest and most common of machine elements is the journal and its bearing, yet fundamental as it is, it is still being subjected to analysis and improvements in design. At the Annual Meeting of the Society in December, 1928, two papers were presented dealing with the effect of clearance and length on the friction of journals, and with journal running positions. Abstracts of these papers appear in MECHANICAL ENGINEERING for August.

The first paper deals with an investigation to provide a reasonably accurate experimental indication of the behavior of small-bore full-journal bearings of various clearances and lengths under normal working conditions.

The second paper indicates that the journal lift in its bearing under adverse conditions, may be much greater than generally expected, resulting in rubbing against the cap and rendering the design of this feature important. The lift will not be serious if the oil is not too heavy for the oil-speed-clearance combination. Side leakage, neglected in the study reported in the paper, is still open for a rigorous analytical investigation.

Tungsten Carbide Tools

WITHIN the past year a new cutting material has been introduced to the engineers of this country. It is composed of tungsten carbide and is sold under various trade names. It has properties that make it possible to cut materials which wear off the edges of other tools very quickly.

Naturally engineers, after hearing the of properties of the tungsten carbide tools, ask for some proof that the tools perform satisfactorily. Two reports on the new material and on experiences with it under service conditions were presented to the A.S.M.E. at Rochester and are published in condensed form in the August issue of MECHANICAL ENGINEERING. Much investigation is still necessary, but it appears at the present time that the new material has presented the machine-tool builder with the problem of redesigning his product to make the most out of the singular properties of tungsten carbide.

Fires From Sparks

LOCOMOTIVES and wood-burning steam boilers in forest areas are accused of setting fires which cause waste and destruction of our natural resources. This is a serious accusation and presents to the engineer the responsibility of proving that it is false or of remedying the situation. In MECHANICAL ENGINEERING for August A. C. Coonradt summarizes the reports of some investigations which were recently made to determine the extent of the damage done by forest fires, the causes of the fires, and to study the fire-prevention equipment available for locomotives and logging engines.

As is usual with such investigations, it was found that the human element of the problem is the most serious. It appears that devices for catching sparks are available and reasonably effective. Carelessness, however, persists, and it is frequently true that the devices, even when installed, are rendered ineffective by careless handling and neglect. It will require much education to emphasize the need for equipping fuel-burning devices with adequate protection and making sure that proper maintenance is observed.

Teaching Advanced Mechanics

EMPIRICAL methods of design are adequate up to a certain point, but there comes a time when a most rigorous theoretical analysis combined with careful experimental verification must take the place of simpler and cruder methods. Few men are naturally gifted for mathematical analyses of original problems in mechanics. The training to fit a man for such work is based upon a thorough working knowledge of mathematics and mechanics.

In the August issue of MECHANICAL ENGINEERING two well-known designers raise the question of the teaching of advanced mechanics in the engineering school and in industry. The papers were presented last May at a meeting of the Applied Mechanics Division of the Society in Rochester. Considerable discussion followed the presentation of the papers, during which various views were expressed as to the proper place for the teaching of advanced mechanics, some believing that the universities should undertake more of this work, while others felt that specialization in such a highly technical subject was unwise in undergraduate courses and should be carried out either in graduate departments, in summer schools, in industry, or by cooperative arrangements between schools and industry. The value to the student of realizing that the problems presented to him were actually met with in design practice and, therefore, had a practical engineering interest, led some to feel that the subject should be taught by engineers with design experience.

Engineering Survey

THE progress of engineering is recorded in the technical press of the world. Every country learns from every other country, every branch of engineering learns from every other branch. A monthly service to engineers is to be found in the Survey of Engineering Literature which is published in MECHANICAL ENGINEERING. Twelve pages of each issue are devoted to abstracts of important articles appearing in the technical press of the entire world. These abstracts combined with the excerpts from the Engineering Index Service which indexes 1700 engineering journals, direct the reader's attention to new developments. Back of both stands the Engineering Societies' Library which is prepared to furnish any article abstracted.